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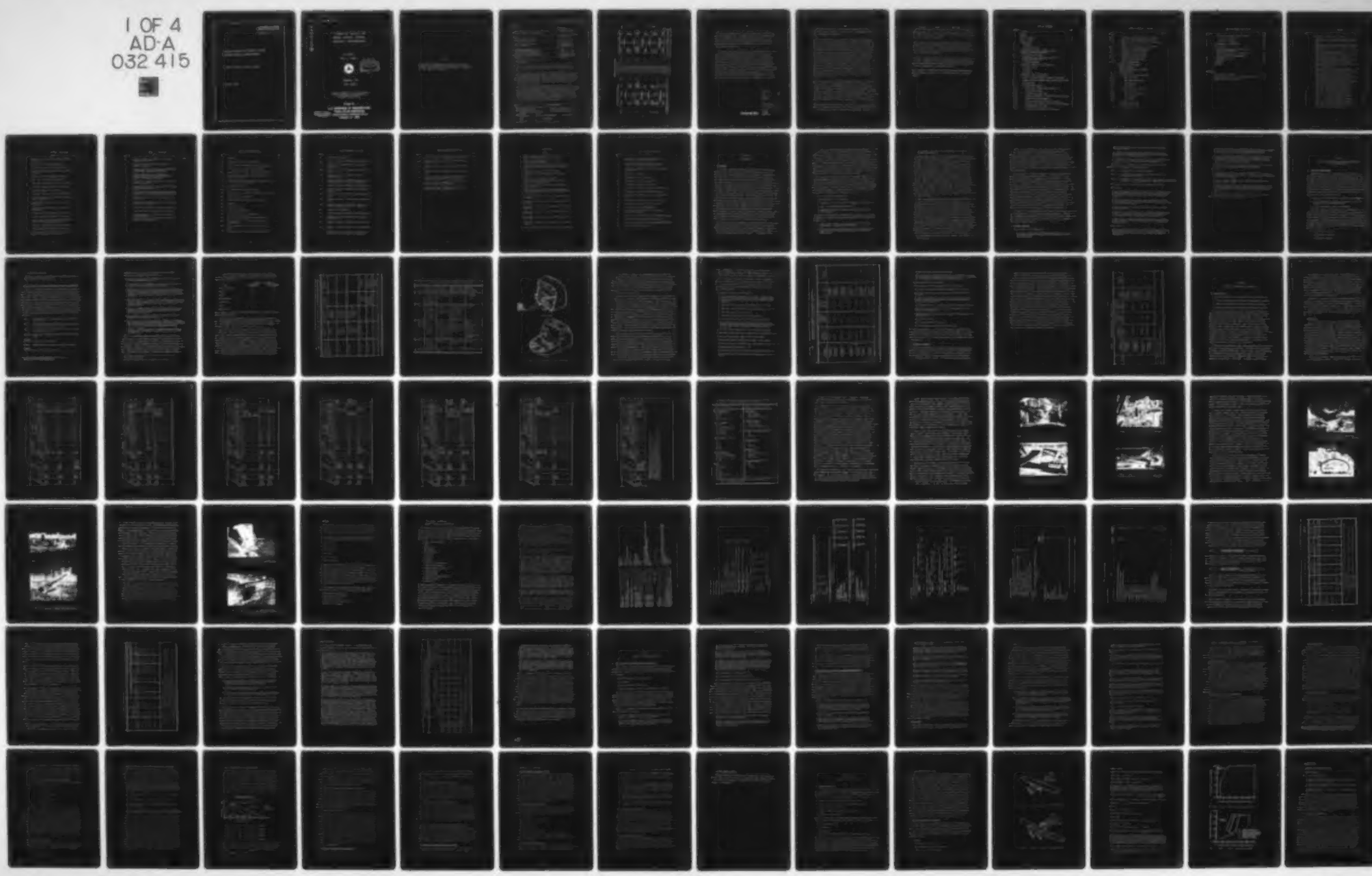

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A METHOD OF ANALYSIS FOR GENERAL AVIATION AIRPLANE STRUCTURAL CRASHWORTHINESS

LOCKHEED-CALIFORNIA COMPANY, BURBANK

SEPTEMBER 1976

Report No: FAA-RD-76-123

A METHOD OF ANALYSIS FOR GENERAL AVIATION AIRPLANE STRUCTURAL CRASHWORTHINESS

Gil Wittlin

Max A. Gamon

September 1976

Final Report

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16. Abstract

The results of the Task I effort to develop a method of analysis of the structural response of general aviation airplane subjected to a crash environment are presented.

A review and evaluation of 8491 accidents obtained from National Transportation Safety Board (NTSB) tapes are presented. Eighteen (18) accident cases from the FAA Civil Aeromedical Institute (CAMI) files are discussed. The performance parameters and structural design characteristics associated with 61 general aviation airplane models are used to establish several airplane categories for light fixed-wing aircraft. An accident data computer program, developed by the Cessna Aircraft Company, is presented.

The requirements for performing computerized crash analysis of general aviation airplanes during probable accident conditions are described. Program KRASH, as modified to meet the requirements of the general aviation industry, is described and assessed with the use of two sets of crash test (stall-spin and overturn) data for a single-engine high-wing and a single-engine low-wing airplane. The mathematical models and the comparison of analysis and test results for both airplanes and accidents are presented. Program KRASH is shown to have the potential to be used as an analytical tool which can facilitate the development of improved crashworthiness in general aviation airplanes.

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Crashworthiness, structural dynamics, light fixed-wing aircraft, mathematical models, large deformations, crushing, energy absorption, accident data,

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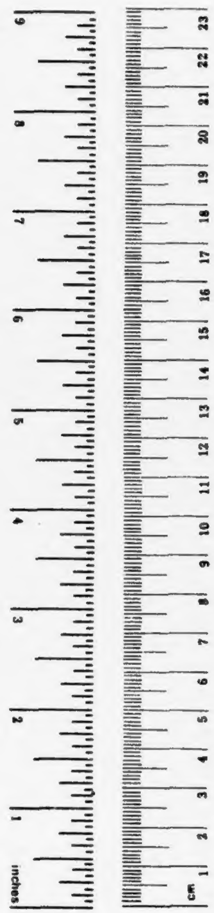
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

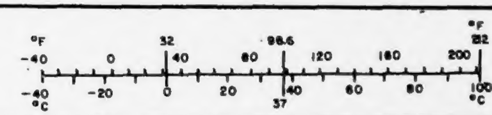
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



FOREWORD

This report was prepared by the Lockheed-California Company under Contract DOT-FA75-WA-3707. The report contains a partial description of the effort performed as part of Task I and covers the period from July 1975 to July 1976. The work was administered under the direction of the Federal Aviation Administration Development Section C, with H. Spicer acting as Technical monitor.

The program leader was Gil Wittlin of the Lockheed-California Company. Important contributions were made to the program by the Cessna Aircraft Company, which participated as a subcontractor. Under the direction of D. J. Ahrens and W. B. Bloedel, the Cessna Aircraft Company provided valuable data with regard to general aviation structure, designs, and procedures and developed a computer program for selecting accident data from NTSB tapes. M. A. Gamon of the Lockheed-California modified program KRASH, which he originally developed. R. Ortiz of the Lockheed-California Company provided valuable computer programming support. P. C. Durup of the Lockheed-California Company assisted in the preparation of reports. The Lockheed effort was performed under the supervision of J. E. Wignot.

SUMMARY

The results of the Task I effort to develop a method of analysis of the structural dynamic response of general aviation airplanes subjected to a crash environment are presented.

Included in this report is the review and evaluation of 8491 accidents obtained from the National Transportation Safety Board (NTSB) tapes for the period 1971 through 1973, the detail evaluation of 18 accident cases from the FAA Civil Aeromedical Institute (CAMI) accident files, and the performance parameters and structural design characteristics associated with 61 general aviation airplane models produced by the major domestic manufacturers. Several categories are established and presented which relate airplane configuration (low-wing, high-wing, single-engine, twin-engine), performance (speed, weight), usage, and occupant capacity. The accident data is related to the airplane categories with the use of a computer program designed to select and process NTSB accident data. This computer program was developed by the Cessna Aircraft Company during this task and is described, in detail, in Appendix A. The accident data is presented with regard to the potential of incurring fatalities during probable accident conditions.

The current and near future computer capability available to the general aviation industry was investigated and found to be compatible with the reasonably large computer programs needed to perform crash analysis. Requirements for performing computerized crash analysis of general aviation airplanes during probable accident conditions are presented. These requirements are compatible with the need to analyze reasonably complex crash conditions, yet, not impose unrealistic and costly investments in specialized manpower and/or equipment to facilitate improved future crashworthy designs.

Program KRASH is briefly described. The modifications to meet the requirements of the general aviation industry, as well as expand KRASH's versatility, flexibility and economy of operation are described. The capability

of program KRASH, modified during Task I, is assessed with the use of two sets of crash test data (stall-spin and overturn) for a single-engine high-wing airplane and a single-engine low-wing airplane. The tests and their results are described in detail. The math models for both airplanes and crash conditions are presented.

Program KRASH is shown to have the potential to be used as an analytical tool which can facilitate the development of improved crashworthiness in general aviation airplanes. The program requires verification with fully instrumented full scale crash tests to ascertain its maximum capability, as well as define its limitations.

The results of the Task I effort are summarized prior to stating the Task I conclusions. Appendices B and C are included and contain film analysis data, airplane model data and typical structural data and configurations for the two airplanes which are analyzed in Task I.

The development of a KRASH User's Manual and structural crashworthiness design guidelines during the Task I effort is described in a separate document.

TABLE OF CONTENTS

Section		Page
	FOREWORD	v
	SUMMARY	vi
	LIST OF FIGURES	xi
	LIST OF TABLES	xvii
1	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	PROGRAM OBJECTIVES	4
2	REVIEW AND EVALUATION OF GENERAL AVIATION AIRPLANE DESIGN CHARACTERISTICS	7
2.1	AIRPLANE CONFIGURATIONS	7
2.2	OPERATIONAL USAGE AND GENERAL STRUCTURAL DESIGN CHARACTERISTICS	8
2.3	AIRPLANE CATEGORIES	17
3	REVIEW AND EVALUATION OF ACCIDENT DATA	20
3.1	SOURCES OF DATA	20
3.2	CAMI DATA	21
3.3	NTSB DATA	39
4	MATHEMATICAL MODEL REQUIREMENTS	56
4.1	GENERAL AVIATION INDUSTRY COMPUTER CAPABILITIES	56
4.2	GENERAL AVIATION AIRPLANE CRASH ANALYSIS REQUIREMENTS	58
4.3	PROGRAM KRASH	59
4.4	MODIFICATIONS TO KRASH	62
4.4.1	Generalized Impact Surface Capability	62
4.4.2	Cabin Volume Change	63
4.4.3	Acceleration Pulse Impact	63
4.4.4	Internal Computation of Element Linear Stiffnesses	64
4.4.5	Member Directional Stresses	64
4.4.6	Internal Computation of Nonlinear Curves	66
4.4.7	Provisions for Modeling Earth Scooping and Plowing	67
4.4.8	Standardization of Terms	67
4.4.9	Refinement of Damping Force Formulation	67

TABLE OF CONTENTS (Continued)

Section		Page
4.4.10	Addition of 'Model Parameter Data' Printout	68
4.4.11	Treatment of Beam Longitudinal Elongation	68
4.4.12	Addition of External Spring Force and Compression Data	68
4.4.13	Separation of Crushing and Friction Energy	68
4.4.14	Revision to the KR Function Usage	69
4.4.15	Revisions to the Input Format	69
4.4.16	Revisions to the Output Format	69
4.4.17	Miscellaneous Coding Changes	70
4.4.18	Addition of Subroutine Echo	70
4.4.19	Use of English Words	71
5	ASSESSMENT OF PROGRAM KRASH	72
5.1	PURPOSE AND METHOD	72
5.2	GENERAL DESCRIPTIONS OF AIRPLANES	73
5.3	CRASH TEST DATA	77
5.3.1	Airplane A Stall-Spin Crash Test	77
5.3.1.1	Test Objectives	77
5.3.1.2	Test Setup and Procedure	77
5.3.1.3	Crash Sequence	78
5.3.1.4	Test Results	81
5.3.2	Airplane B Turnover Crash Test	86
5.3.2.1	Test Objectives	86
5.3.2.2	Test Setup and Procedure	86
5.3.2.3	Crash Sequence	88
5.3.2.4	Test Results	90
5.4	MATHEMATICAL MODEL DATA	95
5.4.1	Airplane A Math Model	95
5.4.2	Airplane B Math Model	100

TABLE OF CONTENTS (Continued)

Section		Page
5.5	COMPARISON OF ANALYSIS AND TEST RESULTS	106
5.5.1	Airplane A Comparison	106
5.5.2	Airplane B Comparison	123
5.6	ASSESSMENT OF PROGRAM KRASH	129
6.0	TASK I RESULTS	132
6.1	REVIEW AND EVALUATION OF GENERAL AVIATION AIRPLANE CHARACTERISTICS	132
6.2	REVIEW AND EVALUATION OF ACCIDENT DATA	133
6.3	MATHEMATICAL MODELING REQUIREMENTS	135
6.4	ASSESSMENT OF KRASH	137
7.0	CONCLUSIONS	140
8.0	REFERENCES	141

APPENDICES

A.	Accident Computer Program	A-1
B.	Representative General Aviation Airplane Structure	B-1
C.	Airplane Math Model and Film Data	C-1

LIST OF FIGURES

Figure	Title	Page
1	Two Typical Engine Mount Arrangements	13
2	Side View of the Post Crash Condition of a Single-Engine Low-Wing Agricultural Airplane (Accident Case 1)	32
3	Side View of the Post Crash Condition of a Single-Engine Low-Wing Commuter Type Airplane (Accident Case 4)	32
4	View Looking Forward of the Post Crash Condition of Instrument Panel (Accident Case 10)	33
5	Side View of the Post Crash Condition of a Single-Engine High-Wing Airplane (Accident Case 10)	33
6	Side View of the Post Crash Condition of a Single Engine High-Wing Airplane (Accident Case 12)	35
7	View Looking Forward of the Instrument Panel Impact Region (Accident Case 12)	35
8	Overall View of the Post Crash Condition of a Single-Engine Low-Wing Airplane (Accident Case 5)	36
9	Side View of the Post Crash Condition of a Single-Engine Low-Wing Airplane (Accident Case 11)	36
10	Side View of the Post Crash Condition of a Single-Engine High-Wing Airplane (Accident Case 14)	38
11	Side View of the Post Crash Condition of a Single-Engine Low-Wing Airplane (Accident Case 16)	38
12	Individual Airplane Output Format, NTSB Data	42
13	Grand Total Summary for 1971 through 1973	43
14	Airplane A, High-Wing Single-Engine Type	74
15	Airplane B, Low-Wing Single-Engine Type	74
16	Weight - c.g. Flight Envelope for Airplane A	76
17	Weight - c.g. Flight Envelope for Airplane B	76
18	Side View of Airplane A Prior to Crash Test	79
19	Side View of Airplane A After the Crash Test	79
20	Crash Test Sequence for Airplane A	80

LIST OF FIGURES - (Continued)

Figure	Title	Page
21	Three-Quarter View of Forward Section Damage (Airplane A)	83
22	Side View of Cabin Damage (Airplane A)	83
23	Top View of Engine Mount Damage (Airplane A)	84
24	Front View of Engine Mount and Firewall Damage (Airplane A)	84
25	Side View of Tail Cone Damage (Airplane A)	85
26	Front View of Wing Damage (Airplane A)	85
27	Side View of Airplane B Prior to the Crash Test	89
28	Side View of Airplane B After the Crash Test	89
29	Crash Test Sequence for Airplane B	91
30	Side View of Forward Fuselage Damage (Airplane B)	93
31	Side View of Cabin Area and Turnover Structural Damage (Airplane B)	93
32	Front View of Engine Mount Failure, Left Side (Airplane B)	94
33	Side View of Engine Mount Failure, Left Side (Airplane B)	94
34	35 Mass, 69 Member Math Model for Airplane A	96
35	21 Mass, 32 Member Math Model for Airplane A	96
36	External Spring Load-Deflection Characteristics Used in the Math Model for Airplane A	99
37	44 Mass, 81 Member Math Model for Airplane B	101
38	25 Mass, 38 Member Math Model for Airplane B	101
39	External Spring Load-Deflection Characteristics Used in the Math Model for Airplane B	105

LIST OF FIGURES - (Continued)

Figure	Title	Page
40	Comparison of Test and Analytical Airplane Deformations (Airplane A)	107
41	Sequence of Cabin Deformation Obtained from Analysis (Airplane A)	108
42	Internal Beam Deflection Time Histories Obtained from Analyses, Cabin Area (Airplane A)	109
43	Internal Beam Deflection Time Histories, Forward Fuselage Structure and Engine Mounts Obtained from Analysis (Airplane A)	110
44	Comparison of Analysis and Test Data for Cabin Deformation (Airplane A)	112
45	External Spring Deflection Time Histories Obtained from Analysis (Airplane A)	113
46	Comparison of Test and Analytical Kinetic Energy Time Histories Obtained from Analysis (Airplane A)	115
47	Time Variation of Analytical Energy Components (Airplane A)	115
48	Time Variation of Strain Energy by Region Obtained from Analysis (Airplane A)	119
49	Cabin Floor Longitudinal Acceleration (Airplane A)	121
50	Cabin Floor Vertical Acceleration (Airplane A)	121
51	Crash Test Sequence of Airplane B as Determined from Photographs	124
52	Operational Velocity/Weight Envelope for Current General Aviation Airplanes	134

LIST OF FIGURES (Continued)

Figure		Page
B-1	Airplane A	B-9
B-2	Engine Mount and Nose Gear Assembly	B-10
B-3	Main Landing Gear Cantilever Spring Cross-Section	B-11
B-4	Fuselage Front and Center Section Assembly	B-12
B-5	Fuselage Front and Center Structure Cross Sections	B-13
B-6	Forward Door Post, Forward Floor Bulkhead, and Carry Thru Structure	B-14
B-7	Forward Door Post, Forward Floor Bulkhead, and Carry Thru Structure Cross Sections	B-15
B-8	Aft Fuselage Structure	B-16
B-9	Aft Fuselage Structure Cross Sections	B-17
B-10	Tailcone and F.S. 95 Bulkhead Structure Cross Sections	B-18
B-11	Wing and Wing Strut Structure	B-19
B-12	Wing and Wing Strut Structure Cross Sections	B-20
B-13	Airplane B	B-21
B-14	Fuselage Structure	B-22
B-15	Engine Mount Arrangement	B-23
B-16	Wing Strut Structure and Attachments	B-24
B-17	Wing Structure, Cross Section and Attachments	B-25
B-18	Main Landing Gear Structure Cantilever Spring Cross Section	B-26
B-19	Vertical Tail Structure, Cross Section and Attachments	B-27
B-20	Fuselage Tail Cone, Cross Section and Attachments	B-28

LIST OF FIGURES (Continued)

Figure		Page
C-1	Profile View of Airplane A	C-6
C-2	Airplane A 35 Mass, 69 Member Math Model Mass Data	C-14
C-3	Airplane A 35 Mass, 69 Member Math Model Member Property Data	C-15
C-4	Airplane A 35 Mass, 69 Member Math Model Damping Data	C-16
C-5	Airplane A 35 Mass, 69 Member Math Model Frequency Data	C-17
C-6	Airplane A 35 Mass, 69 Member Math Model Initial Conditions, Overall Mass and c.g. Properties	C-18
C-7	Airplane A 21 Mass, 32 Member Math Model Mass Data	C-19
C-8	Airplane A 21 Mass, 32 Member Math Model Member Property Data	C-20
C-9	Airplane A 21 Mass, 32 Member Math Model Damping Data	C-21
C-10	Airplane A 21 Mass, 32 Member Math Model Frequency Data	C-22
C-11	Airplane A 21 Mass, 32 Member Math Model Initial Conditions, Overall Mass and c.g. Properties	C-23
C-12	Profile View of Airplane B	C-24
C-13	Airplane B 44 Mass, 81 Member Math Model Mass Data	C-28
C-14	Airplane B 44 Mass, 81 Member Math Model Member Property Data	C-29
C-15	Airplane B 44 Mass, 81 Member Math Model Damping Data	C-30
C-16	Airplane B 44 Mass, 81 Member Math Model Frequency Data	C-31
C-17	Airplane B 44 Mass, 81 Member Math Model Initial Conditions, Overall Mass and c.g. Properties	C-32

LIST OF FIGURES (Continued)

Figure		Page
C-18	Airplane B 25 Mass, 38 Member Math Model Mass Data	C-33
C-19	Airplane B 25 Mass, 38 Member Math Model Member Property Data	C-34
C-20	Airplane B 25 Mass, 38 Member Math Model Damping Data	C-35
C-21	Airplane B 25 Mass, 38 Member Math Model Frequency Data	C-36
C-22	Airplane B 25 Mass, 38 Member Math Model Initial Conditions, Overall Mass and c.g. Properties	C-37
C-23	Airplane B 24 Mass, 37 Member Math Model Initial Conditions and Model Parameter Data	C-38
C-24	Airplane B 40 Mass, 80 Member Math Model Initial Conditions and Model Parameter Data	C-39

LIST OF TABLES

Table	Title	Page
1	Matrix of Airplane Configurations and Maximum Takeoff Weight and Usage	11
2	Structural Design Characteristics of Current General Aviation Airplanes	12
3	Relationship of General Aviation Airplane Configuration to Performance Parameters, Usage and Occupant Capacity	16
4	Categories for General Aviation Airplanes	19
5	Description of Detailed Accident Cases Obtained from CAMI	22
6	Results of Selected CAMI Accident Data	29
7	Summary of Terrain Configurations for Accidents (NTSB Data 1971 through 1973)	49
8	Summary of Accident Data Evaluation (NTSB Data 1971 through 1973)	51
9	Summary of Accident Data Fatalities to Occupants Involved by Subcategories and Accident Types (NTSB Data 1971 through 1973)	54
10	Mass Identification for 21 Mass, 32 Member Airplane A Math Model	97
11	Mass Identification for 35 Mass, 69 Member Airplane A Math Model	97
12	Comparison of Airplane A and Math Model C.G. and Mass Properties	99
13	Mass Identification for 25 Mass, 38 Member Airplane B Math Model	102
14	Mass Identification for 44 Mass, 81 Member Airplane B Math Model	102
15	Comparison of Airplane B and Math Model C.G. and Mass Properties	104
16	Strain Energy Spatial Distribution, Airplane A Analysis	117

LIST OF TABLES (Continued)

Table	Title	Page
17	Comparison of Airplane B Analytical and Test Results for Initial Impact Condition	126
18	Comparison of Airplane B Analytical and Test Results for the Turnover Inverted Impact	126
19	Comparison of Results for the 43 Mass and 24 Mass Airplane B Models	129
20	Modifications to KRASH	136
21	Assessment of KRASH's Capability	139
B-1	Description of Airplane A Structure	B-3
B-2	Description of Airplane B Structure	B-6
B-3	Airplane B Fuselage Structure Tubular Member Sizes	B-8
C-1	Airplane A Structure Test Load-Deflection Data	C-7
C-2	Airplane A Fuselage Test Vertical Load-Deflection Data	C-8
C-3	Airplane A Film Analysis Data (Aft Door Post)	C-9
C-4	Airplane A Film Analysis Data (Aft Window)	C-10
C-5	Airplane A Tailcone Film Analysis	C-11
C-6	Airplane A Film Analysis of Fuselage Rotation and Rotational Velocity	C-12
C-7	Airplane A Film Analysis for Cabin Deformation Change	C-13
C-8	Airplane B Structure Test Load-Deflection Data	C-25
C-9	Airplane B Fuselage Test Vertical Load-Deflection Data	C-26
C-10	Airplane B Film Analysis Data	C-27

SECTION 1

INTRODUCTION

1.1 BACKGROUND

The general aviation industry has grown to the point where their airplanes now carry 90 million people annually and operate out of all the nation's 12,700 airports (Reference 1). Since general aviation airplanes have been proven to be competitive with other forms of transportation, it can be anticipated that the industry's growth rate will continue to accelerate rather than abate. With the increase in air traffic there has been an increase in the number of injuries and fatalities as a result of aircraft accidents. Correspondingly, an increasing effort is being expended to reduce the number of persons injured and the number of deaths resulting from vehicular accidents. The aircraft industry has been mindful of their obligations in this area over a number of years. Through the guidance of the FAA (CAA in the past) great strides have been made in the prevention of accidents by including improved air safety and airworthiness characteristics in the design of aircraft. FAA requirements have been developed and proven by study, tests and operations, that have led to significant improvements to survivability in controlled crashes. These requirements have primarily pertained to seat, harness and seat attachment strength capabilities. General airframe capability requirements for controlled crashes have been in the form of showing that the ditching characteristics and structural strength, under certain impact conditions, will not inhibit egress from the airframe.

The controlled crash requirements have undoubtedly provided some measure of protection for the more severe uncontrolled crash. Efforts such as the joint program sponsored by the FAA (CAA) and the Department of Agriculture in 1950 at Texas A and M have resulted in the development of an agricultural airplane with significant crashworthy features. The designers recognized

that to survive a crash that may be encountered by this airplane, the occupant chances of survival could be increased by placing the hopper, a large mass item, ahead of the pilot which then acted also as crushable material on impact. In addition, the cockpit was designed to provide a protective cage for the pilot during uncontrolled crash conditions and was equipped with a seat and harness of commensurate capabilities. This effort illustrated what could be accomplished with an airplane of a specific configuration having a definable mission and that normally flies at low airspeeds. This agricultural airplane program undoubtedly has resulted in the saving of a number of lives because it formed the basis for later agricultural airplane designs.

FAA sponsored research in the areas of seat harness designs, seat attachment strengths, and fire hazards has improved the occupant's chances to survive under crash conditions. With the progress in technologies and the ability to reduce them to practice, further advancements in crashworthiness can be expected. However, the methods that are to provide the advancements must be adaptable to a number of practical considerations in order to be successful. Some of these considerations are:

- ease of airframe producibility,
- operational use of the airplane,
- adaptability to various preliminary design iterative procedures,
- effect on airframe weight and cost, and
- adaptability to various airframe configurations and airplane crash conditions.

In addition to these practical considerations, the methods that produce the advancements in crashworthiness must reliably predict for occupant safety whether or not

- the structure containing the habitable space will collapse sufficiently to impinge upon the occupant,
- the structure will crush and deform in a controlled predictable manner such that the forces imposed upon the occupant are minimized, and

- the occupant is protected from lethal blows as a result of contact with hardware.

Through efforts sponsored by the FAA, NASA/LRC (Reference 2), and the U.S. Army, Fort Eustis Directorate, methods have been and are being developed which predict the response of airframes and the occupants to impacts encountered in crash conditions. The methods vary in concept, detail, and philosophy; but all approaches have as an end objective the provision of a tool by which the crashworthiness of aircraft can be improved. Since the airframe must properly dissipate the energy imposed by a crash impact, the ability to describe the energy absorption characteristics of the various parts comprising the airframe as well as their interaction is of prime importance. There are a number of programs for predicting the airframe response accurately in the elastic range backed by a great amount of test data. However, the energy in the elastic range of an airframe is minor when compared to the total energy to be absorbed in a crash. Consequently, the success of any methods that are intended to predict airframe response to a crash impact depends primarily on the ability to define the airframe response in the nonlinear range.

Ideally the nonlinear response could be analytically obtained by using a micro-finite element representation of the structure. However, several difficulties have to be overcome before such a representation can become practical such as: definition of the exact characteristics of the element (linear and nonlinear) and how they interface, management of the large amount of data that would be required, and proper handling of the expected large deflections (in the order of 10 times the dimensions of the elements). In addition, as a practical matter, experience with crushing of sheet/stringer types of built-up structures indicates that, although the total performance is repeatable, the detail response of the various parts of the structure will vary as a result of differences, within tolerance, encountered in manufacture. These difficulties with the micro-finite element representation which may be overcome in the future) and the need to provide guidance in selection of adequate crashworthy structural concepts early in the preliminary design stages of an airframe to minimize penalties, suggest that a simpler representation be employed.

Recent efforts, References 3 and 4, have shown that complete vehicle analysis for multidirectional crash conditions can be performed in a practical and cost-effective manner. The programs described in References 3 and 4 involved verification of analytical techniques with full-scale vehicle and substructure testing. The results of these programs and that of the FAA sponsored three-dimensional mathematical model of an aircraft seat, occupant, and restraint system (Reference 5) form the basis for the formulation of analytical methods for evaluating and upgrading the crashworthiness of general aviation airplanes.

The development of analytical methods to assess the crashworthiness capability of airplanes, while important, is not sufficient in itself to assure that general aviation airplanes will be crashworthy in the future. In addition, supporting procedures and rational crash design criteria are required. The development of methods for showing compliance with crashworthiness design criteria requires that particular consideration be given to the crash condition as it applies to different types of airplanes and to different operational requirements which affect the probable crash conditions. In Reference 1 it is stated that 72 percent of all general aviation operations are for commercial purposes (business, air taxi, commuter airlines), 23 percent involves personal transportation and proficiency flying, and 5 percent involves sport flying. Thus, using accident data in conjunction with usage data can provide some indication of the accident conditions that are most likely to produce the greatest amount of fatalities and injuries.

In general, the basic ingredients for a further step forward in improving the crashworthiness of future general aviation airplanes are available; however, refinements and verification of the analytical methods are needed along with formulation of the procedures needed to incorporate the techniques in the iterative design process.

1.2 PROGRAM OBJECTIVES

The objectives of the program are:

- o to develop a computerized mathematical simulation which can predict the dynamic response of general aviation airplanes when exposed to a crash environment,

- o to develop proposed design crash environment criteria for general aviation airplanes,

- o to identify and analyze preliminary design concepts to be used in formulating a potentially optimum crashworthy airframe design configuration for future consideration, and

- o to develop a user's manual for the mathematical simulation including supporting structural crashworthiness design guidelines.

To facilitate the achievement of the stated objectives, the study is performed in the following three technical tasks.

Task I - Development of a mathematical simulation

Task II - Verification of mathematical simulation with full-scale controlled crash test data

Task III - Development of proposed design crash environment criteria and the formulation of an optimum conceptual crashworthiness configuration

The goals for each of the major tasks are delineated as follows.

TASK I GOALS

- o Evaluate and summarize accident data to assist in developing computer modeling requirements, selection of test conditions for verification of a computer simulation and developing crash environment design criteria.

- o Identify general aviation airplane structural design features and the characteristics and crash conditions that the mathematical models must be capable of treating.

- o Evaluate current and future computer capability within the general aviation industry.

- o Modify, as needed, the capability of existing computer program KRASH to meet the requirements for modeling light fixed-wing propeller driven general aviation airplanes under crash conditions.

- o Develop a user's manual and supporting structural crashworthiness design guidelines to facilitate the application of program KRASH by industry members.

TASK II GOALS

- o Provide compatibility between the output of the computerized mathematical model developed in Task I and the input requirements of the mathematical model of an aircraft seat, occupant and restraint system (Reference 5).

- Perform three full-scale controlled crash tests using fully instrumented single-engine high-wing airplanes representing both probable accident conditions and a potentially catastrophic impact condition.

- Verify the crash analysis capability using controlled crash test data for single-engine high-wing airplanes (to be performed during the program) and available crash test data for a twin-engine low-wing airplane and a partial airframe structure.

- Perform correlation studies using test and analytically derived data and refine the mathematical simulation, as required.

TASK III GOALS

- Perform parametric variation studies to demonstrate the capability of the mathematical simulation to model a wide range of airplane configurations and crash conditions.

- Develop proposed design crash environment criteria based on the results of Tasks I and II.

- Formulate an optimum conceptual crashworthiness configuration taking into consideration the crash environment, current and future crashworthy features, and the cost, weight, and performance trade-off penalties.

In this report only Task I related items are presented. Task II and Task III will be reported on at a later date.

SECTION 2

REVIEW AND EVALUATION OF GENERAL AVIATION AIRPLANE DESIGN CHARACTERISTICS

2.1 AIRPLANE CONFIGURATIONS

The development of a mathematical model which is capable of predicting the dynamic response of the structure and occupants for light fixed-wing airplanes during severe, yet survivable, accidents requires that consideration be given to those conditions that influence the manner in which the structure containing habitable space deforms and the forces that are imposed on the occupant from the response of the airplane structure and/or the occupant's motion relative to hardware that he may impact. Examples of airplane configuration design characteristics that potentially influence the load pulse imparted to the seat during a crash are:

- o location of the wing relative to the cabin and occupant position
- o location of engine, or engines, with respect to the cabin; wing mounted (high or low), forward or aft
- o type of landing gear; fixed or retractable

The loads imposed on the airframe and the occupants are a function of airplane usage, structural design, and location of major masses and attachments. Consequently, it is desireable to identify the various airplane configurations and associated characteristics in a manner which will lead to the development of mathematical modeling requirements and rational crash environment design criteria. The following types of airplane configurations represent a majority of the various configurations of airplane designs presently operating:

a. single-engine, low-wing

b. single-engine, high-wing

c. twin-engine, low-wing

d. twin-engine, high-wing

There are a few variations within these categories, such as a tandem push/pull propellor driven airplane.

2.2 OPERATIONAL USAGE AND GENERAL STRUCTURAL DESIGN CHARACTERISTICS

A total of 61 general aviation basic airplane models, produced by the seven leading domestic manufacturers in the industry, were reviewed with regard to their operational usage and structural design characteristics. While not all inclusive, the data is representative of more than 95 percent of the general aviation airplanes currently in operation. Pertinent information such as: probable usage, approximate maximum cruise (75 percent power) and stall speed (flaps down), number of engines, wing position, type of structure and passenger accommodations is noted. The data is compiled from Reference 6 and discussions with industry airplane design personnel. The following airplane manufacturers and their respective models* are represented:

Piper: PA-18, PA-23, PA-24, PA-25, PA-28, PA-31, PA-32, PA-34, PA-36, PA-39

Beech: A24R, B24R, B19, C23, V35B, F33, G33, A36, E55, B55, Baron 58, A60, B60, B80, A50, C90, E90, B99

Cessna: 150, 172, 177, 180, 182, 185, 188, 206, 207, 210, 310, 337, 340, 401, 402, 414, 421

Bellanca: Viking 300A, Champion 7ECA/7GCAA/7KCAB Citabria, 8GCBC, 8KCAB

Grumman-American: AA-1B, AA-5, AA-5B, AgCat

Mooney: Ranger (Mark 21), Chapparral (Super 21), Executive

Rockwell International: 112A, 500S, 685, 690, S2R

* Some models are no longer manufactured.

The categories of usage associated with general aviation airplanes are listed below along with the category general description.

a. Agriculture: Application of chemicals or seeding crops involving low altitude maneuvering flight.

b. Sport, aerobatic: Performance of sporting and aerobatic functions usually involving high maneuvering load factors.

c. Training: Used for instructional purposes usually involving initial flight training. Some of the larger airplanes may be classified as trainers for instrument rating purposes which is not the usage that would lead to the accidents encountered in initial flight training operation.

d. Business, executive: This category may overlap into several areas, such as transport, cargo, and in a few cases testing and developing equipment. These airplanes in some cases may operate out of uncontrolled airfields.

e. Commuter, transport, air taxi: Used to carry people for commercial purposes in very short-range flights and may include operations from uncontrolled airfields.

f. Cargo, freight: Hauling of freight or cargo which can include operations from uncontrolled airfields.

g. Utility: This is a multipurpose usage. Generally, an airplane in this category is used in activities such as ranching, photographing, power and pipeline inspection, ambulance work, and support transportation which requires operating from unprepared airfields.

h. Pleasure: Generally applicable to smaller economical airplanes used mainly for the purposes of flight proficiency and personal transportation.

Most of the airplanes, with the exception of agricultural airplanes, have multiple uses. Some airplane models have as many as three different usages. Of the 61 airplane models included in this evaluation, twenty (20) are twin-engine low-wing airplanes, twenty-four (24) are single-engine low-wing airplanes, including five* agricultural types, thirteen (13) are single-engine high-wing airplanes, and four** (4) are twin-engine high-wing airplanes. The usage of the airplanes, considering the number of engines, can

---

* One biplane is included.

** One has the engines mounted in tandem on the fuselage.

be seen by the following distribution. (Because some models are used for multiple purposes, the total number of usages exceeds the number of models included in the evaluation.)

Usage	Number of Airplanes Twin-Engine	Single-Engine
Executive/Business	18	20
Training	3	11
Commuter	10	10
Aerobatics/Sport	-	11
Cargo/Freight	5	4
Utility	2	7
Agriculture	-	5

Table 1 presents a matrix of airplane configurations as a function of maximum takeoff weight and usage.

Table 2 identifies the general structural design characteristics of the major airframe regions such as the wing, fuselage, engine attachments, landing gear, and empennage associated with different categories of airplanes. (The categories shown in Table 2 are defined in Section 2.3.)

Engine mounts are generally either of a steel tube arrangement type or of a keel type. Figure 1 illustrates an arrangement for each of these two types. The structural characteristics for the two arrangements will differ; and, consequently, the modeling requirements will have to satisfactorily represent their behavior if a reasonably accurate assessment of the entire airframe response is to be performed. The failure of the tubular structure (Figure 1(a)) may likely be through dynamic instability which will occur at a load which is substantially below the yield stress. Wherein failure through elastic instability occurs, the load carrying capability of the structural element tends to decrease rapidly as deflection increases once the failure

TABLE 1. MATRIX OF AIRPLANE CONFIGURATIONS AND MAXIMUM TAKEOFF WEIGHT AND USAGE

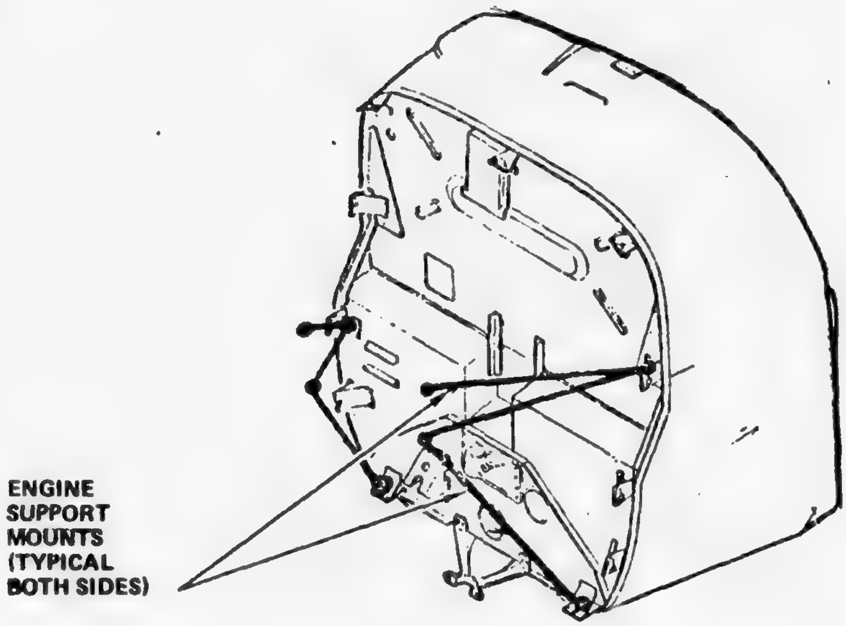
Maximum Takeoff Weight (lb)	Single-Engine Low-Wing	Single-Engine High-Wing	Twin-Engine Low-Wing	Twin-Engine High-Wing
≤ 2000	Trainer Utility	Aerobatic Pleasure Trainer		
2000-2499	Trainer Sport Utility Pleasure	Trainer Business Aerobatic Utility Pleasure		
2500-3999	Business Agriculture Commuter Trainer Utility Pleasure	Business Utility Cargo/Freight Commuter Pleasure		
4000-5999	Agricultural (a)		Business Commuter Cargo	Business Commuter
6000-7999			Business Commuter Cargo/Freight	Business Commuter Cargo/Freight
8000-12500				Business Commuter

(a) Consits of one low wing and one biplane

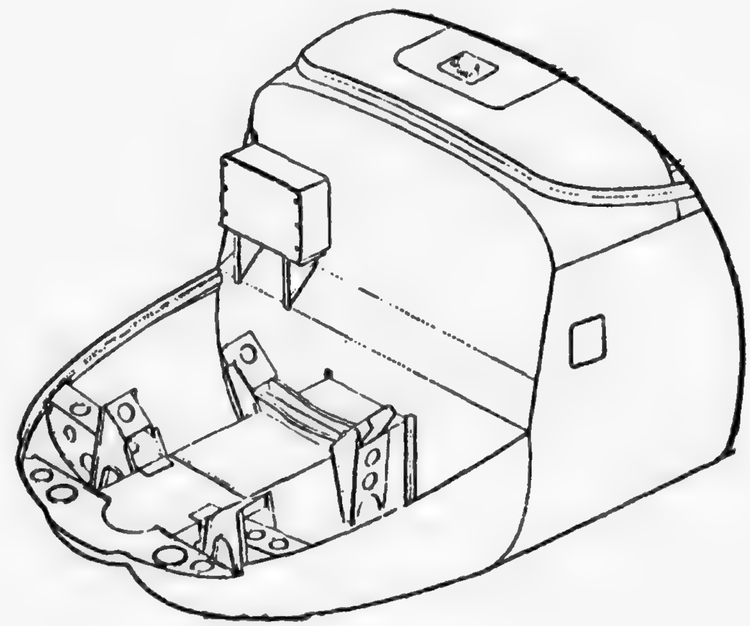
TABLE 2. STRUCTURAL DESIGN CHARACTERISTICS OF CURRENT GENERAL AVIATION AIRPLANES

Structure	Category 1 Single-Engine, Low or High-Wing, Weight < 2500 lb.	Category 2 Single-Engine, Low or High-Wing, Weight 2500-4000 lb.	Category 3, Single-Engine, Low-Wing, (a) Agricultural Use Only, Weight 2500-4000 lb.	Category 4 Twin-Engine, Low or High-Wing, Weight 4000-10900 lb.
Wing	o Braced Wing 1,2 or 3 spar, mostly metal, some wood spars o Cantilever 1,2 or 3 spar, mostly metal, some wood spars	o Cantilever 1,2 or 3 spar mostly metal, some wood spars	o Braced 1 or 2 spar metal construction	o Cantilever 1,2 or 3 spar, mostly metal, some wood spars o One braced, all metal
Fuselage	o All-metal semi-monocoque o Rectangular section welded steel tube o Keel formed by floor and lower skin (cabin), semi-monocoque (rear)	o All-metal semi-monocoque o Weld steel tube o Welded steel tube (cabin), semi-monocoque (rear)	o Rectangular section welded steel tube o Welded steel tube (cabin), semi-monocoque (rear) o Long nose section o Isolated occupant region o Strong turnover structure	o All-metal semi-monocoque
Engine Attachment	o Tubular	o Tubular o Keel	o Tubular	o Tubular o Keel
Landing Gear	o Tail wheel o Tricycle o Cantilever spring main gears o Nonretractable	o Tail wheel retractable o Tricycle retractable and nonretractable o Cantilever spring main gears o Hydraulically activated system	o Tail wheel type o Nonretractable o Cantilever spring main gears	o Mostly tricycle retractable o Some nonretractable with cantilever spring main gears o Hydraulic or electromechanical actuated system
Tail Unit	o Cantilever all-metal o Welded steel tube and channel with fabric covering	o Cantilever all-metal	o Welded steel tube o Cantilever all-metal	o Cantilever all metal

(a) With the exception of one biplane



(a) Tubular



(b) Keel

Figure 1. Two Typical Engine Mount Arrangements

load has been reached. The keel mount arrangement shown in Figure 1(b) can be expected to behave differently. The mount structure for this configuration can be considered to be an integral part of the fuselage, and as such the deformation of the structure will involve crushing that will absorb considerable energy during the plastic deformation associated with the post-failure region. The location of the two different mounts relative to the impact region and terrain will also have an influence on the loading that each of the structures will be exposed to.

The wings in all airplane categories are generally of a cantilever (with the exception of one biplane with flying wires and interplane struts) design with either a one, two, or three spar arrangement. The lighter weight airplanes usually have supporting brace struts for the wing. While most wings are all metal, some of the lighter weight airplanes use wood spars. The wings for the heavier airplanes, particularly the twin-engine airplanes (4,000 pounds and up) generally are unbraced and are of an all metal construction. The empennage for most airplanes is usually an all metal cantilever structure. The landing gear arrangement tends to be a function of weight, the light weight (<2500 pounds) airplane uses a tricycle or tailwheel nonretractable landing gear, wherein the main gears are usually of a cantilevered metal spring design. The agricultural airplanes use tailwheel type nonretractable landing gears, while the heavier single-engine airplanes (2500-4000 pounds) predominantly employ retractable tricycle gears.

Fuselage construction for most of the airplanes (the agricultural airplanes are an exception) are of semi-monocoque construction. A few of the single-engine airplanes and all of the agricultural type airplanes use a welded steel tube construction for the cabin region. In some instances a combination of semi-monocoque and welded tube construction is employed. The agricultural airplanes generally contain design features that are unique such as isolated cockpit, long nose section and strong turnover structure. In all the airplanes the occupant accommodation designs and arrangements vary widely and include individual seats, reclining seats, front and rear facing seats, bench seats, side facing seating, tandem seating, articulated seats, progressively collapsible seats, and a variety of lap belt and shoulder

harness arrangements. Details concerning material characteristics, typical structural components and examples of fastening methods used in the design and construction of general aviation airplanes are presented in Appendix B.

Table 3 presents a grouping of the general aviation airplanes as a function of configuration, maximum takeoff weight, stall speed, operating speed, usage and occupant capacity. Combining the data presented in Tables 1 through 3 provides the following general information on the three major airplane configurations.

a. Twin-engine low and high-wing airplanes

- Maximum takeoff weight range is 3700 pounds to 10,900 pounds, with the majority of twin-engine low and high-wing airplanes weighing between 5300 and 8700 pounds and between 5700 and 9600 pounds, respectively..
- Stall speed (landing configuration) range is 59 to 82 knots.
- Cruise speed range (75 percent of max. power) is 162 to 280 knots.
- Retractable tricycle gears are used.
- Both tubular and keel type engine mounts are used.
- A predominantly semi-monocoque fuselage structure is used.
- Shoulder harnesses and design features which would reduce the potential for occupant injury from impact with structure (padding, no protrusions) are not incorporated as standard features.
- Occupant capacity ranges from 4 to 11 (except B99 airliner).

b. Single-engine low and high-wing airplanes, except agricultural airplanes

- Maximum takeoff weight range is 1560 to 3900 pounds.
- Stall speed (landing configuration) range is 38 to 61 knots.
- Maximum cruise speed (75 percent max. power) range is 100 to 176 knots.
- Occupant capacity ranges from 2 to 6.
- Both retractable and non-retractable type landing gears are used.
- Wing construction is usually unbraced cantilever with two or three spars.

TABLE 3. RELATIONSHIP OF GENERAL AVIATION AIRPLANE CONFIGURATIONS TO PERFORMANCE PARAMETERS, USAGE AND OCCUPANT CAPACITY

Airplane Configuration	Maximum Takeoff Weight (Pounds)	Stall Speed Range, Flap Down (Knots)	Cruise Speed Range, 75 Percent Max. Power (Knots)	Primary Usage	Occupant Capacity
Single-Engine Low-Wing	< 2500	49-54	108-128	Training Pleasure	1-4
Single-Engine High-Wing	< 2500	38-45	100-114	Training Pleasure Aerobatics	2-4
Single-Engine Low-Wing	2500-4000	49-61	132-176	Business Commuting Training Utility	4-7
Single-Engine High-Wing	2500-4000	45-59	124-163	Business Utility Cargo	4-7
Single-Engine Low-Wing (a)	2900-6000	47-59	101-138	Agriculture	1
Twin-Engine Low-Wing	3700-10900	59-82	162-247	Commuting Business Cargo Commuting	4-17 (b)
Twin-Engine High-Wing	4600-10250	61-77	170-280	Business Cargo Commuting	4-11

(a) Includes one biplane

(b) 17 occupants for 1 airplane only, otherwise maximum is 11

- o Fuselage structure is semi-monocoque design.
- o Shoulder harnesses and design features which would reduce the potential for occupant injury from impact with structure (padding, no protrusions) are not generally incorporated as standard features.

c. Single-engine agricultural airplanes

- o The maximum takeoff weight range is 2900 to 6000 pounds.
- o The stall speed (landing configuration) range is 47 to 59 knots.
- o The maximum cruise speed (75 percent max. power) range is 101 to 138 knots.
- o Crashworthy design features such as overturn structure, shoulder harness, padded instrument panel, isolated cockpit and long nose structure are incorporated.
- o The fuselage consists of a welded steel tube truss type of structure.
- o Wing construction is generally braced cantilever design with the exception of one biplane.
- o Landing gears are non-retractable tailwheel with cantilevered spring steel main gears.
- o Single place cockpit.
- o Payload carried forward of the pilot.
- o A tubular engine mount support structure is used.

The design characteristics of the various categories of general aviation airplanes described herein indicate that there is a tendency for a particular manufacturer to generally use the same type of design features, including structure, because of past success, engineering cost considerations and ease of manufacture.

2.3 AIRPLANE CATEGORIES

The review and evaluation of the various airplane configurations discussed in Sections 2.1 and 2.2 indicate that there are several categories that can be established to facilitate the accident data evaluation, the development of mathematical modeling requirements and the development of crash environment design criteria. The crash environment depends primarily

on airplane usage and operating speeds while the modeling requirements, to ascertain the survivability of occupants during a crash, include consideration of not only the crash environment but also the airplane structural configuration. From Table 3 it can be seen that light single-engine airplanes (<2500 pounds) have similar usage and operational requirements, irrespective of the wing and engine configuration. This situation implies that they may be exposed to the same crash environment. How the airplanes respond to the crash environment can be influenced by the location and method of attachment of the major mass items (i.e. wing, engine). Similarly it can be expected that the heavier weight (2500-4000 pound) single-engine airplanes (except agricultural configurations) and the twin-engine airplanes, because of their differences in weight, operating speeds and usage, can each be exposed to their own particular crash environment, which is not a function of the wing and engine locations. (Agricultural airplanes, because of their unique mission, can be exposed to an entirely different crash environment than that of the other airplanes.) Consequently, the definition of the crash environment for general aviation airplanes can be obtained from as little as four categories, as shown in Table 4. On the other hand, the requirements for modeling the different airplanes and assessing current capability to protect occupants during a severe crash may indicate the need for additional categories. Thus subcategories (i.e. 1A, 1B, 2A, 2B, and 4A, 4B), shown in Table 4, are also established and used as noted in the following sections of this report.

TABLE 4. CATEGORIES FOR GENERAL AVIATION AIRPLANES

Category	Airplane Configuration	Maximum Takeoff Weight (Pounds)	Stall Speed Range Flap Down (Knots)	Cruise Speed Range 75 Percent Max. Power (Knots)	Primary Usage	Occupant Capacity
1	Single-Engine A. Low-Wing B. High-Wing	<2500	38-54	100-128	Training Sport Aerobatic Pleasure	1-4
2	Single-Engine A. Low-Wing B. High-Wing	2500-4000	45-61	124-176	Business Utility Commuting Training	4-7
3	[a] Single-Engine Low-Wing	2900-6000	50-53	101-122	Agriculture	1
4	Twin-Engine A. Low-Wing B. High-Wing	>4000-10900	59-82	162-280	Business Cargo Commuting	4-11 [b]

(a) Includes one biplane

(b) Except for 1 airplane accommodates 17

SECTION 3

REVIEW AND EVALUATION OF ACCIDENT DATA

3.1 SOURCES OF DATA

The primary sources for the accident data used in the study are:

- FAA Civil Aeromedical Institute (CAMI), Oklahoma City, Oklahoma
- The National Transportation Safety Board (NTSB), Washington, D.C.
- General aviation accident investigation summaries and reports

The FAA Civil Aeromedical Institute is situated in Oklahoma City. Crash investigators from CAMI cover only a selected number of accidents that mostly occur in the states of Oklahoma, Texas and Arkansas. The records for each accident contain, when available, the airplane make and model identification, the flight condition under which the accident occurred (i.e. crop spraying maneuvers, loss of power, stall on turn, obstacle impact), impact angle, post crash behavior, stopping distance, structural damage, use and condition of seat belts and harness, number of occupants involved, occupant injuries/fatalities, and cause of injuries/ fatalities. Some of the accident reports contain photographs of the airplanes in the post crash condition. Copies of 18 accident reports, obtained from CAMI, were reviewed and evaluated. The results of this effort are contained in Section 3.2 of this report.

The National Transportation Safety Board compiles records of accidents that have occurred throughout the nation. The data from these accidents are stored on tape by calendar year. While the tapes may be accessed such that a requester may solicit several sheets of data concerning each accident, much of the information needed to support this program does not appear as a regular part of the format. The Cessna Aircraft Company,

prior to developing the program described herein, developed a computer software program which utilizes portions of the accident data from the NTSB tapes. While the format of the Cessna accident software program provides useful information it was decided that in order to meet the objectives of this project the software program should be refined. The changes to the software program and the results of the NTSB data evaluation are presented in Section 3.3. Details of the software program (a copy of which has been submitted to the FAA) including a User's Manual and listing are presented in Appendix A.

In addition to the NTSB and CAMI data, several reports which provide summaries of accident data and/or descriptions of selected accidents were reviewed. The information obtained from these reports was included as part of the accident review and evaluation. In particular, the information contained in References 7, 8, 9, 10 and 11 was reviewed and the applicable data is integrated into the discussions contained in Sections 3.2 and 3.3.

3.2 CAMI DATA

At the initiation of this program, CAMI investigation reports (References 7 and 8) were reviewed. The latter reference contains a summary of 110 accident investigations and presents data describing the accident, identifying the airplane, on the location of the accident, on the accident type, concerning airplane damage, and data on occupant injury. The summary data provided in Reference 8 was used as a guide in the selection of the detailed accident cases that were obtained from CAMI. Photographs and case histories came from an on-site search of CAMI records. The criteria for selecting a CAMI recorded accident for detail review required that the particular accident report contain information regarding one or more of the following: flight path angle at impact; impact velocity; stopping distance; airplane pitch, roll or yaw angle at impact; and availability of photographs.

Data for the 18 accident cases selected from CAMI files for detail review, are presented in Table 5. Table 6 is a summary of the results

TABLE 5. Description of Detailed Accident Cases Obtained From CAMI(f)

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight (lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations: Lap Belt Used	Lap Belt Failed	Shoulder Harness Install	Shoulder Harness Used	Shoulder Harness Failed	Occupant Injury Data (h): Fatal (a)	Critical (b)	Serious (c)	Moderate (d)	Minor/None (e)	Probable Area of Fatal Injury	Probable Area of Occupant Impact	Post Crash Fire	Remarks
1	Piper PA-25 N6128Z	Single-Engine, Low-Wing		Stalled (Aerial Application	45	NA	1. Fwd nose strut crump-led. 2. Cock-pit bent.	1. Des-troyed by tree	Hard Ground	Yes	Yes	Yes	Yes	Yes	Yes				1C			1.Inst. Panel at wind-shield 2. Hopper 3. Rudder Pedal	No	
2	Cessna C-140 N90045	Single-Engine, High-Wing		Contacted Power Line (Enroute)	30	64	Fwd Nose Sec-tion		Hard Ground	NA	NA	NA	NA	NA	NA		1C					1.Con-trol wheel 2. Rudder Pedal 3. Lower Fuse-lage Struc-ture	No	
3	Cessna C-182B	Single-Engine, High-Wing		Enroute: Fin sheared by tele-phone wire over lake, dived into water from 18'	NA	NA	Fin torn off by wire		Water	NA	NA	NA	NA	NA	NA	1P 1C						1. Instr. Panel		Asphyxiation

TABLE [illegible]. Description of Detailed Accident Cases Obtained From CAMI([illegible]) ([illegible])

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight (lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations: Lap Belt: Used	Lap Belt: Failed	Shoulder Harness: Install	Shoulder Harness: Used	Shoulder Harness: Failed	Occupant Injury Data (h): Fatal (a)	Critical (b)	Serious (c)	Moderate (d)	Minor/None (e)	Probable Area of Fatal Injury	Probable Area of Occupant Impact	Post Crash Fire	Remarks
4	Piper PA-24-250	Single-Engine, Low-Wing	2900	Struck Ground (Enroute)	0	305	Fuselage Broke Aft of Cabin		Mud	2*	Yes	No	NA	NA	NA			1P	1C 2P			1.Inst. Panel 2.Control Wheel 3.Seat Back	No	*Two Passenger Seat Back
5	Mooney M-20 N2570W	Single-Engine, Low-Wing		Hit Trees & Impact Ground (Forced Landing)	9	NA		Damaged by Trees	Grassy pasture	NA	NA	NA	NA	NA	NA	1P	1C 1P			*	1.Inst. Panel 2.Control Wheel	Yes (Engine Comp)		*Fatality was involved in auto accident. Victim dead before crash.
6	Piper PA-28 N0730J	Single-Engine, Low-Wing		Impact Ground (Enroute)	45	NA	Destroyed	Destroyed	Swamp Like	2	Yes	No	No	-	-	1C 1P				Extensive Lacerations & Internal injuries	1.Inst. Panel 2.Fwd Cockpit Structure	No		

TABLE 5. Description of Detailed Accident Cases Obtained From CAMI(f) (Cont'd)

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight (lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations, Lap Belt: Used	Lap Belt: Failed	Shoulder Harness: Install	Shoulder Harness: Used	Shoulder Harness: Failed	Occupant Injury Data (h): Fatal (a)	Critical (b)	Serious (c)	Moderate (d)	Minor/None (e)	Probable Area of Fatal Injury	Probable Area of Occupant Impact	Post Crash Fire	Remarks
7	Piper PA-22 N2642A	Single-Engine, High-Wing		Stalled (Takeoff)	< 10	159	Crump-led	Crump-led	Black Top Road	No	Yes	1*	NA	NA	NA	1C		3P			1. Severe Lacerations & Bruises (Upper Head & Torso) 2. Severe Internal Injuries	1. Inst. Panel & Control Wheel	No	*Pilot Seat Belt Fitting Failed
8	Luscombe 8A N71153 1946	Single-Engine, High-Wing		Unstable Air Down Draft (Enroute)	20	NA	Wind-Shield Broken		River Bed	NA	Yes	No	NA	NA	NA					1C		1. Inst. Panel 2. Rudder Pedal	No	
9	Cessna C-150 N23177 68	Single-Engine, High-Wing	1600	Hit Tree (Enroute)	15	75	Tail Section Broke Off		Pasture	No	Yes	No	NA	NA	NA			1C 1P				Suspect Upper Cabin Structure	No	

TABLE [illegible] Description of Detailed Accident Cases Obtained From CAMI [illegible]

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight (lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations: Lap Belt: Used	Lap Belt: Failed	Shoulder Harness: Install.	Shoulder Harness: Used	Shoulder Harness: Failed	Occupant Injury Data (h): Fatal (a)	Critical (b)	Serious (c)	Moderate (d)	Minor/None (e)	Probable Area of Fatal Injury	Probable Area of Occupant Impact	Post Crash Fire	Remarks
10	Piper PA-22 N2955P	Single-Engine, High-Wing		Hit Turbulence from a Commercial jet taking off. Diving into ground (landing).	50	NA		L. Wing Torn Crumpled	Hard Soil	1*	Yes	No	NA	NA	NA			1C 1P				1. Inst. Panel 2. Control Wheel 3. Rudder Bars	No	*Front Seat Pulled loose from track
11	Beech C55 N4807J	Twin-Engine, Low-Wing		Impacted Ground in R.H. Turn (Enroute) ⚠1	50	38	Destroyed	Destroyed	Grassy Field	2*	Yes	1**	NA	NA	NA	1C 1P					High G Impact Occupants thrown from A/C		No	*One seat thrown 190', one seat thrown 267' **Belt buckle failed
12	Piper PA-22 N8723C	Single-Engine, High-Wing		Hit Fence (attempted landing after engine failure in takeoff)	12	48	Fuselage broken fwd of tail assy.	L. Wing Crumpled	Hard Ground	NA	No	No	NA	NA	NA			1C	1P	3P		1. Inst. Panel 2. Control 3. Post	No	

⚠1 Considered Non-survivable

TABLE 5. Description of Detailed Accident Cases Obtained From CAMI(f) (Cont'd)

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight(lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations: Lap Belt: Used	Cabin Accommodations: Lap Belt: Failed	Cabin Accommodations: Shoulder Harness: Install	Cabin Accommodations: Shoulder Harness: Used	Cabin Accommodations: Shoulder Harness: Failed	Occupant Injury Data (h): Fatal (a)	Critical (b)	Serious (c)	Moderate (d)	Minor/None (e)	Probable Area of Fatal Injury	Probable Area of Occupant Impact	Post Crash Fire	Remarks
13	Ercoupe N2208H	Single-Engine, Low-Wing		Landed short in thick growth of trees (landing)	20	NA	1.Nose Gear 2.Lwr Fuselage 3.Windshield	Wing L.E. Damaged Substantially	Woods	NA	NA	No	NA	NA	NA			1C				1.Inst. Panel 2.Windshield	No	
14	Piper J-3 N3507K	Single-Engine, High-Wing		Hit side of hill (coyote hunting 50' altitude flying)	45 ∫ 80	NA	Fwd side structure buckled	NA	Hilly	2*	Yes	1	NA	NA	NA	1C 1P					1. Upper Head & Torso & Extremities. 2.L. foot dislocated	1.Inst. Panel 2.Fwd tubular cockpit structure 3.Rudder Bar	No	*1.Fwd Seat legs bent & broken. 2.Wooden seat bottom splintered.
15	Beech J-35 N7209B	Single-Engine, Low-Wing		Hit trees on mountain (landing thru overcast)	5	NA	1.Fuselage broken. 2. Engine broke off.	NA	Mountains	No	Yes	1*	2	1	No			1C	1P			1. Thrown thru windshield. 2.Fwd aft load against restraint system.	No	*Pilot seat belt buckle inadverently released.

TABLE 5. Description of Detailed Accident Cases Obtained From CAMI(?) ([illegible])

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight(lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations: Lap Belt Used	Cabin Accommodations: Lap Belt Failed	Cabin Accommodations: Shoulder Harness Install	Cabin Accommodations: Shoulder Harness Used	Cabin Accommodations: Shoulder Harness Failed	Occupant Injury Data (h): Fatal (a)	Critical (b)	Serious (c)	Moderate (d)	Minor/None (e)	Probable Area of Fatal Injury	Probable Area of Occupant Impact	Post Crash Fire	Remarks
16	Piper PA-24 N6028P	Single-Engine, Low-Wing		Struck fence & dam, landed in farm pond. (power failure in takeoff)	45	NA	1.Main Gear & Nose Gear Separated. 2.Windshield broken.	NA	Earth-Dam	1*	2**	No	NA	NA	NA	1C 2P					1.Head lacerations & bruises. Drowned. 2. Massive Head Injuries (No seat belts).	1.Inst. Panel.	No	*L. aft leg of R. front seat broken. **Rear passengers did not use lap belt.
17	Mooney 20	Single-Engine, Low-Wing		Hit Tree during cruise	15	NA	Extensive		Farm Land	Yes	Yes	No	No	NA	NA	1C						Impact with Inst. Panel.		

TABLE 5. Description of Detailed Accident Cases Obtained From CAMI(f) (Cont'd)

Accident Case	Airplane Designation	Airplane Configuration	Maximum Takeoff Weight(lb) (g)	Accident Type	Kinematics: Impact Angle (degrees)	Kinematics: Deceleration Distance (feet)	Structural Damage: Fuselage	Structural Damage: Wings	Terrain Composition	Seat Failures	Cabin Accommodations: Lap Belt: Used	Cabin Accommodations: Lap Belt: Failed	Cabin Accommodations: Shoulder Harness: Install	Cabin Accommodations: Shoulder Harness: Used	Cabin Accommodations: Shoulder Harness: Failed	Occupant Injury Data (h): Fatal (a)	Occupant Injury Data (h): Critical (b)	Occupant Injury Data (h): Serious (c)	Occupant Injury Data (h): Moderate (d)	Occupant Injury Data (h): Minor/None (e)	Occupant Injury Data (h): Probable Area of Fatal Injury	Occupant Injury Data (h): Probable Area of Occupant Impact	Post Crash Fire	Remarks
18	Monocoupe 110 N12350	Single-Engine, High-Wing		Stalled, Impacted ground (engine failure in take-off. Attempted LH turn back to field. Stalled at 200' altitude)	60	NA	Crumpled	Crumpled	NA	Yes	Yes	1*	NA	NA	NA	1C**	1P				Skull & Extremity Fractures	1. Inst. Panel 2. Cabin Structure	No	*RH seat belt stitching failed. **Death within 24 Hours

(a) Fatal. Death within 24 hours.
(b) Critical. Lacerations, fractures and bruises with dangerous bleeding, concussion with unconsciousness longer than 30 minutes, depressed fractures of skull, dangerous intracranial damage, dangerous internal injuries, etc.
(c) Serious. Concussion with unconsciousness 5 to 30 minutes, comminuted fractures of nose, arms, legs, and back, loss of eye, internal injuries, etc.
(d) Moderate. Mild bone fractures, mild concussion with unconsciousness less than 5 minutes, "disfiguring" lacerations and bruises without severe hemorrage, etc.
(e) Minor or None. Minor cuts, bruises, sprains, broken or loosened teeth, dislocated nose, etc.
(f) Data obtained from FAA AERONAUTICAL CENTER, CAMI, Oklahoma, Project No. 74-770-120A (01545) May 1975
(g) Data is entered in this column only when such information was supplied in the CAMI Report.
(h) C denotes crew and P denotes passengers.

TABLE 6. RESULTS OF SELECTED CAMI ACCIDENT DATA

Frequency of Occurrence	
Phase of Operation	
Takeoff	4
Landing (a)	4
Cruise	8
Aerial Application	2
Type of Accident	
Stall	3
Ground/Water Impact	5
Contact w/tree/object	5
Landing Short	1
Side of Hill	2
Miscellaneous	2
Angle of Impact (degrees)	
0-10	4
11-20	5
21-30	1
31-45	3
46-90	4
Unknown	1
Roll/Yaw Attitude	
Significant Roll/Yaw	3
Slight or No Roll/Yaw	9
Overturn	2
Unknown	4
Terrain	
Hard Soil	7
Grassy Land	4
Water	1
Mud/Swamp	2
Trees	1
Mountainous/hilly	2
Unknown	1

Damage, Failures, Injuries	
Cabin Damage	
Intact, None	4
Minor, Moderate	8
Substantial, Destroyed	6
Structure Damage	
Intact, None	0
Minor, Moderate	7
Substantial, Destroyed	11
Impact with Control Panel/Knobs	
Yes	15
No	1
Unknown	2
Seat Failures	
Yes	9
No	3
Unknown	6
Injuries (Total)	
Fatalities	15
Serious and/or Critical	15
Moderate	6
Minor, None	4
Lap Belt Failures (TOTAL)	
Yes	6
No	27
Unknown	7

(a) Generally impact occurs with tree, object, or ground, due to bad weather or stall.

of the review of the 18 accident cases. Included in the summary are 9 single-engine high-wing airplanes, 8 single-engine low-wing airplanes and one twin-engine low-wing airplane.

An examination of Table 6 shows that for the 18 CAMI accident cases, 38 percent of the occupants died and another 38 percent of the occupants received serious or critical injuries. Seat failures occurred in 50 percent of the 18 accidents. In those accidents in which lap belts were used, lap belt failures occurred 15 percent of the time. A very significant statistic is that in 15 of 16 reported cases, impact of occupants with the instrument panel and/or control knobs occurred. In only two of the 18 accidents that were reviewed were the airplanes equipped with shoulder harnesses and only one person involved in these accidents used the harness. The occupant that used his harness suffered a minor injury while, in the same accident, the other occupant, who did not use his harness, was thrown through the windshield and received a severe injury. This distribution of accidents for the 18 selected cases by phase of operation and accident type is similar to the distribution noted in the NTSB data evaluation. The angle of impact is ≤ 45 degrees in 13 of 17 (77 percent) cases in which this information was reported. This impact angle data is consistent with the overall data presented in References 7 and 8, which show the impact angle to be ≤ 45 degrees in 20 of 28 accidents (71.4 percent) and 22 of 28 accidents (78.6 percent), respectively. The cabin damage assessment of the 18 cases shows moderate, minor or no cabin damage in 67.5 percent of the accidents where this information is reported. Reference 9 states that the cabin remains intact in 67.3 percent of the accidents. Substantial structural damage occurs in approximately 60 to 65 percent of the accidents.

The following discussion of the 18 accidents describes and illustrates typical crashes and the resultant damage to the structure and injury to the occupants. One of the prime concerns in reviewing accident data is to relate the critical structural regions for typical crashes to general aviation airplane mathematical modeling requirements.

Figure 2 shows the post crash condition of a single-engine low-wing agricultural airplane (case 1, Table 5). This particular airplane was reported to have stalled, while engaged in aerial application of insecticide, nosed over, and impacted hard soil at an approximate angle of 45 degrees. The pilot was wearing a helmet, shoulder harness and a 3-inch seat belt. The helmet penetrated the windshield and was torn off. The seat belt and shoulder harness broke in the webbing. The pilot was thrown straight forward and suffered moderate head and extremity injuries. In Figure 2 it can be seen that the tubular framework of the cockpit maintained its integrity, with regard to cabin volume. The impact energy was absorbed by the forward section of the fuselage as can be seen by the substantial damage forward of the cockpit.

Figure 3 shows the results of a single engine low wing airplane (case 4, Table 5) used primarily as a commuter. The accident report states that the airplane encountered bad weather and contacted the ground in a flat attitude and skidded 305 feet up and over a small hill. All the occupants were wearing seat belts and none of the belts failed. No shoulder harnesses were in the aircraft. One serious and three moderate injuries were sustained. The two front occupants impacted the upper and lower section of the instrument panel with their heads and extremities, respectively. All the seats stayed intact. In Figure 3 it can be seen that the forward fuselage, the cabin region and the rear fuselage did not undergo large deformations which is consistant with the kinetic energy absorbed in the post-impact slideout of 305 feet.

Figures 4 and 5 illustrate the post-crash condition of the instrument panel and airplane, respectively, of a single engine high wing airplane (case 10, Table 5). The airplane, with the pilot and one passenger on board, while landing at an airport, was caught in the turbulent wake of a commercial jet and crashed on the runway. No shoulder harnesses were in the aircraft. Both occupants, who were wearing seat belts, sustained severe injuries. The seats tore loose during the crash and the occupants impacted the instrument panel. The airplane which impacted the ground initially with its left wing sustained a crushed forward

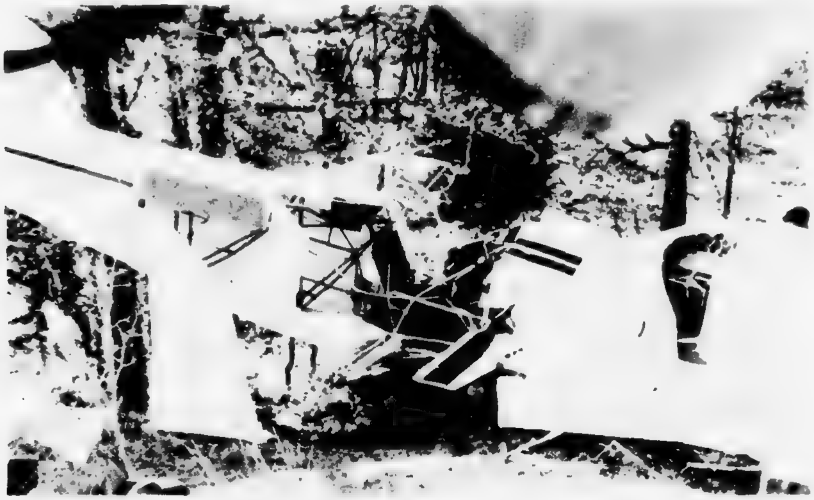


Figure 2. Side View of the Post Crash Condition of a Single-Engine Low-Wing Agricultural Airplane (Accident Case 1)

Figure 3. Side View of the Post Crash Condition of a Single-Engine Low-Wing Commuter Type Airplane (Accident Case 4)

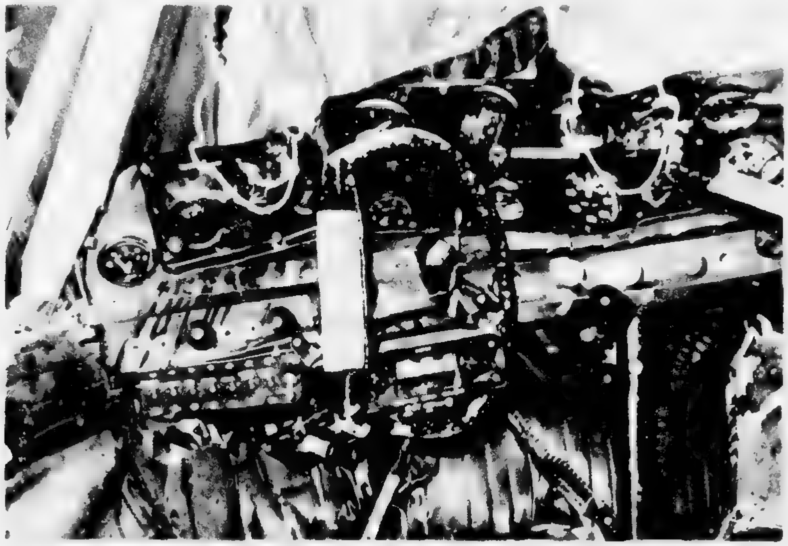


Figure 4. View Looking Forward of the Post Crash Condition of Instrument Panel (Accident Case 10)

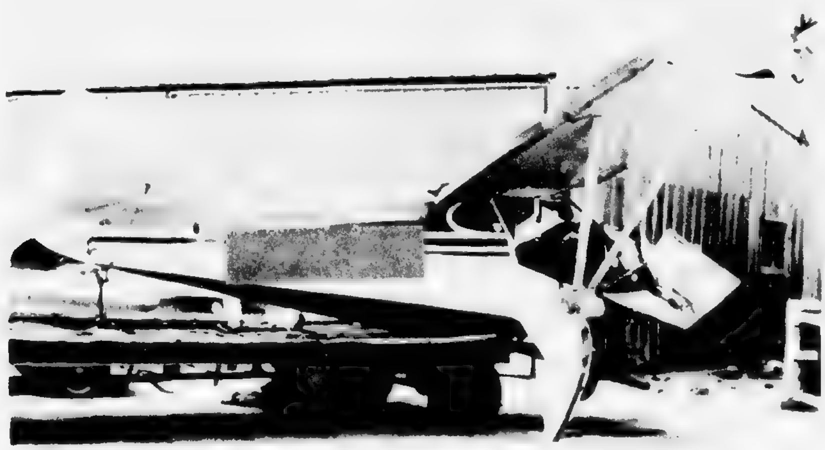


Figure 5. Side View of the Post Crash Condition of a Single-Engine High-Wing Airplane (Accident Case 10)

fuselage and crumpled left wing (not shown). However, as can be seen in Figure 5, the aircraft structure from approximately the location of wing brace attachments at the fuselage to the tail shows no significant external damage. The white head outlines in Figure 4 show where the heads of the occupants impacted the instrument panel.

Figures 6 and 7 depict the post crash condition of the structure and the cockpit, respectively, for a single-engine high-wing airplane (case 12, Table 5). The accident report states that the airplane, containing a pilot and four passengers, had just taken off and was approximately two miles from the airport when the engine started to miss. As the pilot returned to land, the engine stopped and the pilot made an emergency landing in a field. The left wing tip and landing gear struck the top strand of a four foot high fence. The airplane experienced two impacts. Seat belts were in use and they did not fail. No shoulder harnesses were installed. The occupants were thrown to the left and forward. The pilot suffered a severe injury, the co-pilot a moderate injury and the three passengers in the rear received minor or no injuries. Figure 7 shows the dent at the top of the instrument panel caused by the co-pilot's head on impact. The crushing sustained by the left wing and lower forward fuselage and the failure of the left main and nose gears can be seen in Figure 6. Most of the impact energy was absorbed by the lower forward fuselage.

Figures 8, 9, 10 and 11 show the post crash damage for several different accidents. Figure 8 shows the post crash damage to a single-engine low-wing airplane (case 5, Table 5) when the right wing first contacted muddy ground after the airplane hit the tops of small trees. Figure 8 shows that the damage to the airplane is primarily confined to the wing tips, engine and forward fuselage. For the most part, the cabin appears in good condition although the forward lower fuselage absorbed most of the impact energy. The airplane shown in Figure 8 does not look as if it sustained damage as a result of inverting, which the accident report indicates took place. The three occupants in the airplane experienced critical and fatal injuries. Figure 9 shows the post crash

Figure 6. Side View of the Post Crash Condition of a Single-Engine High-Wing Airplane (Accident Case 12)

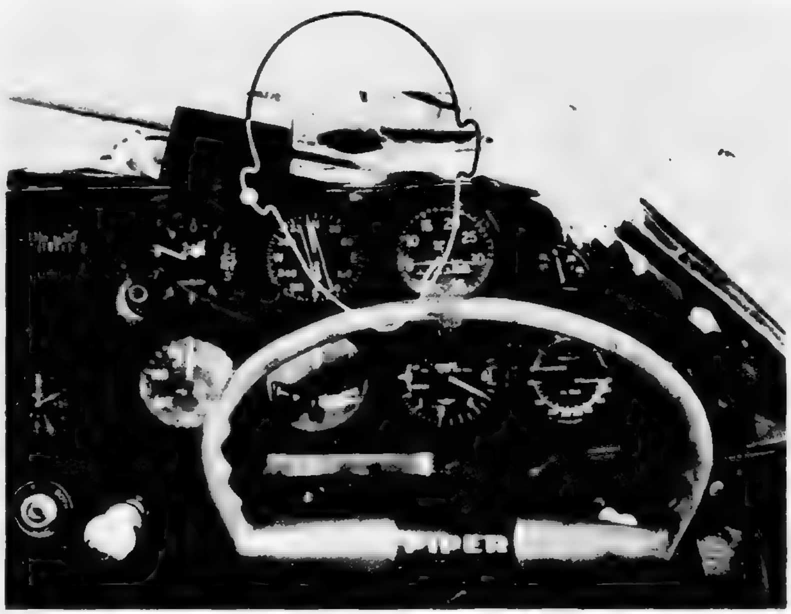


Figure 7. View Looking Forward of the Instrument Panel Impact Region (Accident Case 12)

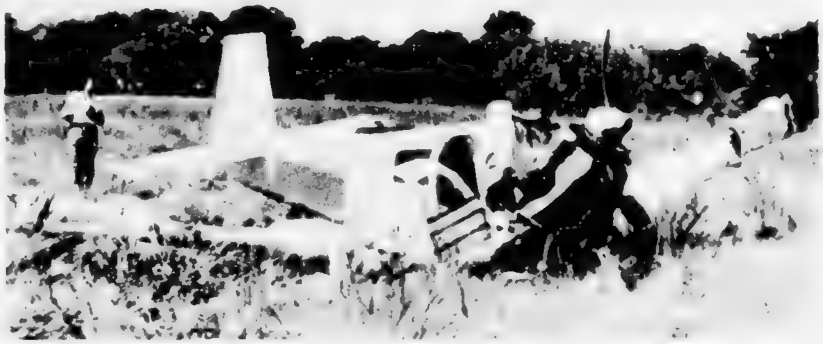


Figure 8. Overall View of the Post Crash Condition of a Single-Engine Low-Wing Airplane (Accident Case 5)

Figure 9. Side View of the Post Crash Condition of a Single-Engine Low-Wing Airplane (Accident Case 11)

condition of a low-wing single engine airplane (case 11, Table 5) which landed short in a thick growth of trees. The airplane sustained forward fuselage and wing leading edge damage. All other visible structure appears to have escaped damage. The pilot, who was flying alone, experienced a severe injury as a result of impacting the instrument panel. Figure 10 shows the post crash condition of a single-engine high-wing airplane (case 14, Table 5). The airplane, containing a pilot (rear) and one passenger (front), crashed into the side of a hill while flying low on a hunting mission. Both occupants were fatalities. Although they were wearing seat belts, the pilot's seat belt failed at its attachment allowing the pilot to be thrown on top of and over the front seat passenger. Both occupants impacted the instrument panel. Structural damage to the forward fuselage, wing, landing gear and forward cabin region appears severe. Figure 11 shows the post crash condition of a single-engine low-wing airplane (case 16, Table 5). While on takeoff, the airplane with a pilot and two passengers failed to clear a fence. The nose gear and nose section struck an earthen dam, bounced over it and sank in the pond. (The photograph was taken after the airplane was removed from the pond). Occupants were thrown forward and to the left. All three occupants drowned. However, both front seat occupants received massive head injuries caused by impact with the instrument panel. The cabin remained intact. The interior and instrument panel (not shown) appeared in good condition after the crash.

The results of the evaluation of the selected CAMI accident cases are in general agreement with the overall conclusions in Reference 8 and 10. The CAMI data indicates that, while the cabin remains intact, occupants are still exposed to a high injury or fatality potential and it appears that improved crashworthiness can be obtained by providing restraint systems and airframe structural deformation characteristics that are consistent with the physiological capabilities of the occupants.

Figure 10. Side View of the Post Crash Condition of a Single-Engine High-Wing Airplane (Accident Case 14)

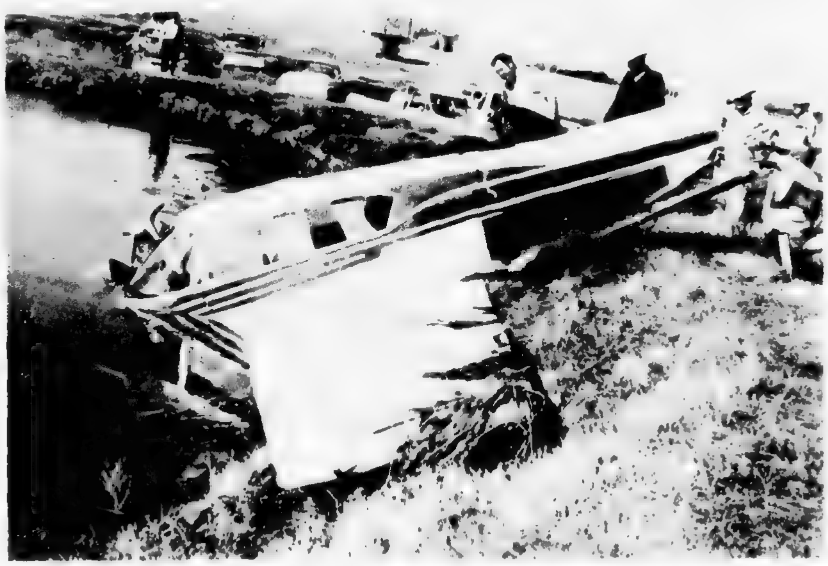


Figure 11. Side View of the Post Crash Condition of a Single-Engine Low-Wing Airplane (Accident Case 16)

. NTSB DATA

A current Cessna software program, used to survey accident reports produced by the NTSB, is modified in accordance with the requirements of the program described in this report. The details of the software program including a User's Manual and listing are provided in Appendix A.

The program searches the NTSB accident tapes and summarizes all case histories which contain data concerning any of the following items.

- Impact Angle
- Impact Velocity
- Stopping Distance
- Seat Failure
- Seat Belt Failure
- Attitude at Impact

A summary of the NTSB accident tape data files is assembled by individual airplane models by manufacturer and a grand summary of all airplanes, irrespective of manufacturer or model, is also compiled. The individual accident cases and aircraft model summaries are screened to insure that no irrelevant accident data is retrieved from the NTSB tapes. The screening criteria is identical for the individual accident cases and the model summaries with departure from this norm occurring only in the summary printout under the "Major Phases of Operation".

Initial screening is accomplished by selecting those accidents which involve airplanes produced by the following seven manufacturers:

Beech Aircraft Corporation
Bellanca Aircraft Corporation
Cessna Aircraft Company
Gruman American Aviation Corporation
Mooney Aircraft Company

Piper Aircraft Corporation

Rockwell International Corporation

The models chosen from those of the above manufacturers are limited to a gross weight of less than 12,500 pounds (FAR 23) and are propeller driven. A secondary screening of the NTSB tapes is accomplished by selecting accidents of certain types which are identified in the NTSB accident data files. The following list identifies the types of accidents used in the search.

Ground Water Loop-Swerve
Stall
Wheels Up
Hard Landing
Nose Over/Down
Roll Over
Overshoot
Undershoot
Collision with Ground/Water
Collided with Obstacles
Dragged Wingtip, Float, or Pod*
Airframe Failure*
Engine Tearaway*
Engine Failure or Malfunction*
Propeller Failure*
Turbulence*

The above grouping of accidents is selected to delineate occurrences which would cover a majority of the hazards that might be encountered in general aviation operations. Also, the above list should include those accidents in which major airframe failure, loss of cabin crashworthiness capability or occupant injury may occur. Some of the types of accidents which are not included because they are not relevant to the study are; collision between aircraft, lightning strike, hail damage, bird strike, ditching and missing aircraft. The accident types listed above that are noted by an asterik are considered secondary data and are not necessarily related to impact conditions.

Tertiary screening of the NTSB tapes is accomplished by selecting "Phases of Operation" which are identified in five (5) major categories in the NTSB code classification manual. Three major phases of operation (takeoff, in-flight and landing) are used to screen the accident tapes for the summary and also the individual accident case print out. This technique is employed throughout the individual accident case retrieval. However, in the summaries under "Major Phases of Operation" two additional phases of operation (static and taxi) were selected for data retrieval and are printed out under the heading of "other".

The modifications to the Cessna program for handling accident data provide the following three types of printout.

- Concerning a Particular Airplane - The following data, if available from the accident reports, is provided: airplane identification number; accident date; airplane manufacturer; structural damage; nature of the flight; terrain; type of accident; phase of operation; cause/factor injury index; qualitative assessment of impact severity; estimated acceleration levels; severity of the damage; and data regarding stopping distance, direction of principal deceleration, seat belt failures, seat failures, use of shoulder harnesses and death due to fires, if information is available. A sample printout of a modified accident report, obtained from NTSB tapes, is shown in Figure 12.

- Concerning an Airplane Model by the Year - Derivatives of a model are combined (i.e. Cessna Model 150 includes 150, A150, A150K, etc.). Included in the summary are airplane manufacturer and model designation, date; (number of accidents and occupants involved, and number of accidents with fatalities and injuries), total number of injuries; flight conditions, accident types, impact conditions, airplane cabin occupant capacity and impact area (terrain).

- Concerning Accident Data for All Airplanes for a Given Period of Time - The format of the data is the same as that for the individual airplane summary. A sample of this output is shown in Figure 13.

The NTSB accident summary for 1971 through 1973 includes a survey of accidents. A total of 8,491 accidents are surveyed. Of this total 8,030 (95%) involved airplane models that are used to establish the different airplane categories presented in Table 3 (Section 2.2). Foreign manufactured airplanes that are final assembled or marketed by the major domestic

```
DATE . . . . . . . . . . . . . . . . . . . . . . . . .    04/22/72
AIRCRAFT MAKE . . . . . . . . . . . . . . . . . . . . .   AERO COMDR
AIRCRAFT MODEL  . . . . . . . . . . . . . . . . . . . .   500-B

AIRCRAFT DAMAGE . . . . . . . . . . . . . . . . . . . .   DESTROYED
FIRE AFTER IMPACT . . . . . . . . . . . . . . . . . . .   YES
KIND OF FLYING (GENERAL AVIATION) . . . . . . . . . . .   PLEASURE/PERSONAL TRANSP

TYPE OF ACCIDENT, FIRST . . . . . . . . . . . . . . . .   COLLIDED WITH
TYPE OF ACCIDENT, FIRST . . . . . . . . . . . . . . . .   TREES

PHASE OF OPERATION, FIRST . . . . . . . . . . . . . . .   LANDING
PHASE OF OPERATION, FIRST . . . . . . . . . . . . . . .   FINAL APPROACH
AIRPORT PROXIMITY . . . . . . . . . . . . . . . . . . .   WITHIN 5 MILES
RUNWAY COMPOSITION  . . . . . . . . . . . . . . . . . .   CONCRETE
RUNWAY LENGTH . . . . . . . . . . . . . . . . . . . . .   10000
TERRAIN (TYPE) OF AIRPORT . . . . . . . . . . . . . . .   HILLY

                        CAUSE / FACTOR
CAUSE / FACTOR  . . . . . . . . . . . . . . . . . . . .   IMPROPER IFR OPERATION
CAUSE / FACTOR  . . . . . . . . . . . . . . . . . . . .   ATTEMPTED OPERATION W/KNOWN DEFICIENCIES IN EQUIPMENT
CAUSE / FACTOR  . . . . . . . . . . . . . . . . . . . .   LACK OF FAMILIARITY WITH AIRCRAFT
CAUSE / FACTOR  . . . . . . . . . . . . . . . . . . . .   LOW CEILING
CAUSE / FACTOR  . . . . . . . . . . . . . . . . . . . .   RAIN
CAUSE / FACTOR  . . . . . . . . . . . . . . . . . . . .   FOG

                        INJURY - INDEX
                                                            F  S  M  N  Z  T
PILOT . . . . . . . . . . . . . . . . . . . . . . . . .     1              1
PASSENGERS  . . . . . . . . . . . . . . . . . . . . . .     4              4
TOTAL ABOARD  . . . . . . . . . . . . . . . . . . . . .     5              5

REMARKS . . . . . . . . . . . . . . . . . . . . . . . .    ACFT RADIOS OPERATED INTERMITTENTLY WHILE ENROUT
                                                          E. DESCENDED BLO MDA ON ILS APCH.1 HR DUAL IN TYPE
AIRCRAFT SERIAL NUMBER  . . . . . . . . . . . . . . . .   00001384-138
RATE OF DECELERATION  . . . . . . . . . . . . . . . . .   EXCESSIVE
DIRECTION OF PRINCIPAL DECELERATION . . . . . . . . . .   FORWARD
STOPPING DISTANCE . . . . . . . . . . . . . . . . . . .     85
DAMAGE SEVERITY - IMPACT (NON-TRANS. AIRCRAFT)            EXTREME
```

Figure 12. Individual Airplane Output Format, NTSB Data

AIRCRAFT MANUFACTURER / MODEL - ALL / ALL

MAXIMUM TO WEIGHT - POUNDS

WING CONFIGURATION

NUMBER OF ENGINES / LOCATION -

GENERAL INFORMATION

TOTAL NUMBER OF ACCIDENTS SURVEYED - - - - - - - - - - - - - 8491

TOTAL APPLICABLE ACCIDENTS SURVEYED - - - - - - - - - - - - - 7471

TOTAL NUMBER OF OCCUPANTS - - - - - - - - - - - - - - - - - - 15609

AVERAGE NUMBER OF OCCUPANTS PER ACCIDENT - - - - - - - - - - 2

NUMBER OF ACCIDENTS WITH AT LEAST ONE (1) FATAL INJURY - - 1217

NUMBER OF ACCIDENTS WITH AT LEAST ONE (1) SERIOUS INJURY - 638
AND NONE MORE SERIOUS

NUMBER OF ACCIDENTS WITH AT LEAST ONE (1) MINOR INJURY - - 1032
AND NONE MORE SERIOUS

NUMBER OF ACCIDENTS WITH NO INJURY - - - - - - - - - - - - - 4589
AND NONE MORE SERIOUS

***** TOTALS OF SERIOUSNESS OF INJURIES *****

	FATAL	SERIOUS	MINOR	NONE
PILOT	1134	584	956	4795
COPILOT	81	21	15	91
PASSENGERS	1257	544	997	4767
* OTHER	48	40	47	310

* OTHER INCLUDES DUAL STUDENT & CHECK PILOT

FLIGHT CONDITIONS -

Figure 13. Grand Total Summary For 1971 through 1973

FLIGHT CONDITIONS -

TOTAL NUMBER OF ACCIDENTS WHICH OCCURRED DURING THE FOLLOWING FIVE MAJOR PHASES OF OPERATION / NUMBER OF ACCIDENTS WITH AT LEAST ONE FATALITY WHICH OCCURRED DURING THE MAJOR PHASE

TAKEOFF - -	1355 /	113
IN FLIGHT -	2450 /	888
LANDING - -	3666 /	216
OTHER - - -	375 /	16
NOT REPORTED	11 /	6

NINE (9) MOST FREQUENT MINOR PHASES OF OPERATION WITHIN THE FIRST THREE MAJOR PHASES ABOVE LISTED IN DESCENDING ORDER OF FREQUENCY

MINOR PHASE OF OPERATION	TOTAL NO. OF ACCIDENTS	********* INJURIES ********** FATAL	SERIOUS	MINOR	NONE
1. NORMAL CRUISE	477	411	200	366	186
2. INITIAL CLIMB	383	231	193	354	152
3. FINAL APPROACH	252	125	148	221	62
4. UNCONTROLLED DESCENT	249	511	25	14	1
5. LEVEL OFF/TOUCHDOWN	201	27	69	237	143
6. ROLL	106	3	16	120	45
7. TRAFFIC PATTERN-CIRCLING	101	67	59	71	30
8. GO-AROUND	98	46	52	84	24
9. OTHERS	590	503	269	309	115

EIGHT (8) MOST FREQUENT TYPES OF ACCIDENTS WITHIN THE FIRST THREE MAJOR PHASES ABOVE LISTED IN DESCENDING ORDER OF FREQUENCY

TYPE OF ACCIDENT	TOTAL NO. OF ACCIDENTS	********* INJURIES ********** FATAL	SERIOUS	MINOR	NONE
1. ENGINE FAILURE OR MALFUNCTION	719	289	318	743	300
2. COLLISION WITH GROUND/WATER	569	961	180	129	44
3. COLLIDED WITH	549	480	255	309	118
4. STALL	540	550	271	256	94
5. GROUND-WATER LOOP-SWERVE	119	1	23	141	43
6. OVERSHOOT	99	19	40	114	76
7. OTHERS	285	228	104	224	115
8. NOT REPORTED					

NOTE -- OTHER IS SUM OF ALL ACCEPTABLE PHASES AND TYPES EXCEPT THOSE LISTED

Figure 13. Grand Total Summary For 1971 through 1973 (Continued)

IMPACT CONDITIONS

TOTAL NUMBER OF ACCIDENTS WHICH RECORD IMPACT ANGLES - 27

IMPACT ANGLE NUMERICAL SUMMARY -

AVERAGE ANGLE DEGREES	IMPACT ANGLE CATEGORIES - DEGREES						
	0 -15	16-30	31-45	46-60	61-75	76-90	90+
62	4	2	5	1	2	13	

TOTAL NUMBER OF ACCIDENTS WHICH RECORD IMPACT VELOCITY - 2

IMPACT VELOCITY NUMERICAL SUMMARY -

AVERAGE VELOCITY KNOTS	IMPACT VELOCITY CATEGORIES - KNOTS				
	1-30	31-60	61-90	91-120	120+
148			1		1

TOTAL NUMBER OF ACCIDENTS WHICH RECORD STOPPING DISTANCES - 499

STOPPING DISTANCE NUMERICAL SUMMARY -

AVERAGE STOPPING DISTANCE - FEET	STOPPING DISTANCE CATEGORIES - FEET						
	1 -60	61-120	121-180	181-240	241-300	301-360	360+
194	174	87	73	48	38	17	62

OCCUPANT INJURY NUMERICAL SUMMARY AT RESPECTIVE AIRCRAFT DAMAGE SEVERITY INDICES -

DAMAGE SEVERITY	* * * * FATAL	OCCUPANT SERIOUS	INJURY MINOR	* * * * NONE
EXTREME	1701	152	18	1
SEVERE	96	59	14	4
MODERATE	21	6	3	2
MINOR	17	1	4	
NONE				5

Figure 13. Grand Total Summary For 1971 through 1973 (Continued)

AIRCRAFT CABIN ACCOMMODATIONS -

NUMBER OF ACCIDENTS IN WHICH SEAT FAILURE OCCURRED - - -	149
TOTAL NUMBER OF SEAT FAILURES - - - - - - - - - - - - - -	328
NUMBER OF ACCIDENTS IN WHICH SEAT BELT FAILURE OCCURRED -	204
TOTAL NUMBER OF SEAT BELT FAILURES - - - - - - - - - - -	344
* NUMBER OF SHOULDER HARNESS USED - - - - - - - - - - - - -	237
* NUMBER OF SHOULDER HARNESS FAILURES - - - - - - - - - - -	21
* NUMBER OF CRASH HELMETS USED / NOT USED - - - - - - - - -	442 / 68

* APPLICABLE TO AGRICULTURAL AIRCRAFT ONLY

IMPACT AREA

PERCENT OF ACCIDENTS WHICH OCCURRED IN PARTICULAR TERRAIN TYPE

TERRAIN TYPE	PERCENT ACCIDENT OCCURRENCE (1)
UNKNOWN/NOT REPORTED	52
LEVEL,FLAT	19
ROLLING	8
MOUNTAINOUS	6
DENSE WITH TREES	4
HILLY	4
WATER-LAKES,RIVERS,ETC.	3
PLOWED	2
OTHER	1
CITY AREA	1

(1) PERCENT IS RATIO OF PARTICULAR TERRAIN TO NUMBER OF ACCIDENTS SCREENED

Figure 13. Grand Total Summary For 1971 through 1973 (Continued)

CAUSE / FACTOR GRAND SUMMARY

CAUSE / FACTOR SUMMARY

CAUSE	FATAL ACCIDENTS	NONFATAL ACCIDENTS
* * PILOT * *		
1. INADEQUATE PREFLIGHT PREPARATION AND/OR PLANNING	200	829
2. FAILED TO OBTAIN/MAINTAIN FLYING SPEED	304	630
3. FAILED TO MAINTAIN DIRECTIONAL CONTROL	3	740
4. IMPROPER LEVEL OFF	4	687
* * COPILOT * *		
1. IMPROPER LEVEL OFF		5
2. IMPROPER LEVEL OFF		4
* * DUAL STUDENT * *		
1. IMPROPER LEVEL OFF	8	25
2. IMPROPER LEVEL OFF		32
* * CHECK PILOT * *		
1. IMPROPER LEVEL OFF		7
2. IMPROPER LEVEL OFF		1
* * AIRFRAME * *		
1. BRAKING SYSTEM (NORMAL SYSTEM)		65
2. NORMAL RETRACTION/EXTENSION ASSEMBLY		59
* * MISCELLANEOUS ACTS, CONDITIONS * *		
1. OVERLOAD FAILURE	52	1067
2. FUEL EXHAUSTION	27	370
3. FUEL STARVATION	24	264
4. MATERIAL FAILURE	13	262

Figure 13. Grand Total Summary For 1971 through 1973 (Continued)

manufacturers are included in the final summary but not in the development of airplane categories. This accounts for the difference between 8491 accidents and 8030 accidents. The data is reviewed with regard to the potential for an occupant fatality to occur (for accidents in which at least one injury is reported), the distribution of accidents by terrain conditions, the total number of occupants involved, the total number of fatalities, and the total number of accidents. To facilitate the evaluation, two ratios are established. The first ratio (Ratio No. 1) is for all accident types and relates the total number of fatalities to total number of occupants involved in all accidents. This ratio is defined below as:

$$\text{Ratio No. 1} = \frac{\text{total number of fatalities}}{\text{total number of occupants}} \text{ (all accidents)}$$

The second ratio (Ratio No. 2) defines the number of fatalities relative to the number of occupants involved for a particular accident type. This ratio is established for accident types such as the stall, collision with ground/water and collision with obstacle.

$$\text{Ratio No. 2} = \frac{\text{number of fatalities}}{\text{number of occupants}} \left(\begin{matrix}\text{for a particular accident type} \\ \text{involving an injury}\end{matrix}\right)$$

Obviously, larger airplanes. which carry more passengers, will have a higher ratio of fatalities to accidents than the smaller airplanes. In dividing by the number of occupants involved for each particular accident type a more rational manner of comparing different size and weight airplanes on an equal basis can be utilized.

Both ratios are intended to give an indication of the occupant's chance for a fatal injury potential in each category of airplane as well as in all the airplanes combined.

Table 7 presents a summary of the accident distribution for general aviation airplanes in accordance with the terrain configuration. The summary is based on a sampling of airplanes for the three airplane categories (categories 1, 2 and 4 of Table 4) for which the majority of accident data

TABLE 7. SUMMARY OF TERRAIN CONFIGURATIONS FOR ACCIDENTS (NTSB DATA 1971 THROUGH 1973)

	All Airplanes		Single-Engine, High-Wing (a)		Single-Engine Low-Wing (b)		Twin-Engine Low-Wing (c)	
Type Terrain	Number of Accidents	Percent	Number of Accidents	Percent	Number of Accidents	Percent	Number of Accidents	Percent
Level, Flat	1,444	46.0	339	40.9	175	37.0	43	36.1
Rolling	676	21.6	186	22.5	193	26.0	22	18.5
Mountainous	422	13.5	146	17.6	92	19.4	19	16.0
Hilly	253	8.1	91	11.0	53	11.2	13	10.9
Dense with Trees	253	8.1	67	8.0	30	6.4	15	12.6
City	84	2.7	--	--	--	--	7	5.9
	3,132	100	829	100	473	100	119	100

(a) Based on Category 1B Type Airplanes, 2-4 Occupants, Sport, Trainer, Pleasure, and Business Usage.

(b) Based on Category 2A Type Airplanes, 2-6 Occupants, Sport, Trainer, and Business Usage.

(c) Based on Category 4 Type Airplanes, 4-10 Occupants, Executive, Commuter, and Cargo Usage.

is available. Although the number of accidents per terrain configuration varies somewhat for the different airplane categories, each category of airplanes has about the same percent of accidents per terrain configuration. Single-engine airplanes have accidents in rolling, mountainous and hilly terrains, somewhat more often, percentage-wise, than do the twin-engine airplanes. The reason may be associated with the fact that engine failure in a twin-engine airplane does not mean that a landing needs to be made immediately.

Table 8 provides a summary of the accident data using the different categories of accidents, the accident data pertinent to the models within each of the categories and the two ratios described earlier. Ratio No. 1 will identify the more crashworthy categories of airplanes, whether it be due to the structural design or the crash environment, to be those with lower ratios than that of the composite of all airplanes. On this basis the smaller lighter weight airplanes and the agricultural airplanes appear to be more crashworthy than the other airplanes.

The data presented in Table 8 indicates that the most probable accident for the lighter weight airplanes (<2500 pounds) is a stall condition. The most fatal accidents for heavier weight airplanes (>2500 pounds) are associated with collisions with ground or water. This particular type of accident can be either controlled or uncontrolled in nature. The NTSB information does not provide sufficient data with which to delineate between the two situations. Miscellaneous accident types, such as a hard landing, undershoot, overshoot, ground swerve, generally do not result in fatalities. The 1971 through 1973 NTSB data indicates that less than 5 percent of the occupants involved in these types of accidents received fatal injuries. This value is extremely low by comparison to the overall average of 45.5, 70.7, and 39 percent, respectively, for all categories of airplanes involved in the three major accident types shown in Table 8.

From the data shown in Table 8, of the three major accident types, the most survivable appears to be an accident which is initiated by contact with some obstacle. One possible reason for this is that this type of

TABLE 8. SUMMARY OF ACCIDENT DATA EVALUATION (NTSB DATA 197[illegible] THROUGH 1973)

Category (a)	Number of Accidents Surveyed	Ratio No. 1 (b)	Ratio No. 2 (c)			Order of Occurrence of Accident Type (Percent Distribution (d))		
			Stall	Collision with Ground	Collision with Obstacle	Stall	Collision with Ground	Collision with Obstacle
1 (<2500)	4502	.122	.439	.652	.326	1(37.5)	3(29.2)	2(33.3)
2 (>2500)	2245	.149	.408	.625	.346	3(22.3)	1(49.1)	2(28.6)
3 (Agriculture)	601	.081	.300	.222	.273	2(39.0)	3(6.5)	1(54.5)
4 (2 Engines)	682	.283	.728	.788	.695	3(21.3)	1(44.3)	2(34.4)
All Categories	8030	.147	.455	.707	.390	3(32.5)	2(33.6)	1(33.9)

(a) See Table 4 for Complete Definition of Categories.

(b) Ratio No. 1 = (Total Number of Fatalities/Total Number of Occupants) All Accidents

(c) Ratio No. 2 =(Number of Fatalities/Number of Occupants) For a Particular Accident Type Involving an Injury and/or Fatality

(d) Accident Types Involving an Injury. Percentage distribution is for the three types shown. Applicable to the Ratio No. 2.

accident occurs close to the ground at reduced airplane operating speeds (i.e. landing, approaches and takeoffs) and the impact angle usually is flat. The least chance of occupant survival occurs in collisions with the ground. With the exception of agricultural airplanes, at least 62 percent of the occupants that are involved in this type of accident sustain a fatal injury. While collisions with the ground represent a wide range of accidents (e.g. forced landings, bad weather, misjudged altitude and/or clearance), most of the accidents generally occur at speeds approaching that of cruise.

The agriculture airplanes (Category 3) which have a takeoff weight comparable to that of the single-engine airplanes used primarily for business, utility, commuter and cargo purposes (Category 2), demonstrate considerably more crashworthiness capability for all the three major accident types. Factors that most likely account for this difference are:

- Agricultural airplanes are designed with specific crashworthy features (overturn pylon, long fuselage, harness, isolated cockpit) that are compatible with their mission.

- Agriculture airplanes may crash under more controlled conditions, usually after hitting some obstacle.

- The pilots of agricultural airplanes generally are more experienced in emergency conditions than the average general aviation pilot.

While the agricultural airplanes provide a greater chance of occupant survivability during a crash, the pilot will sustain a fatal injury in about 30 percent of the accidents in which injuries occur.

The data presented in Table 8 indicates that benefits due to improvements in crashworthiness design for the twin-engine airplanes may provide the biggest payoff in reducing the degree of severe or fatal injuries that are sustained relative to the number of people involved. However, on an absolute basis there have been substantially more fatalities in single-engine airplane accidents than in twin-engine airplanes because there are substantially more single-engine airplanes in operation. Therefore, from a life saving point of view, if a priority is to be assigned, emphasis should be placed on upgrading the crashworthiness characteristics of

single engine airplanes.

Table 9 sets forth the accident data for the categories wherein a distinction is made between a low-wing configuration and a high-wing configuration and indicates that:

- With the exception of the comparisons between high-wing and low-wing configurations for both light airplanes (< 2500 pounds) and two-engine airplanes in accidents involving collision with obstacles, the deviation from the mean value does not exceed $\pm$ 8.5 percent for all accident types and airplane categories noted in Table 9. This trend indicates that for the airplane and accidents considered and the period of time covered (1971-73) the location of the wing, for a particular category of airplane, is not very significant with regard to fatality potential in injury incurred accidents.

- The low-wing, single-engine airplane experiences approximately the same rate of fatalities in accidents involving stall as do the high-wing, single-engine configurations. The data for the lower weight (< 2500 pounds) airplane indicate a slightly higher fatality rate for the high wing airplane (45.7 versus 38.6 percent). This trend is reversed for the higher weight (2500-4000 pound) category (38.5 percent versus 43 percent).

- The lower weight (< 2500 pounds) low-wing, single-engine airplanes experience approximately the same rate of fatalities in accidents involving collision with ground/water as do the high-wing, single engine airplanes (66.3 versus 64.5 percent). For the heavier weight (2500 to 4000 pounds) single-engine airplanes, the fatality rate for the ground/water type of accident is slightly in favor of high-wing configurations (67.4 versus 56.8 percent).

- The heavier weight (2500 to 4000 pounds) low-wing, single-engine airplanes experience approximately the same rate of fatalities in collision with obstacle type accidents as compared to the high-wing configuration (35.3 versus 34.2 percent). The lower weight (< 2500 pounds) low-wing, single-engine airplanes exhibit higher rates of fatalities for this type of accident when compared to the high-wing configuration (38.3 versus 28.3 percent). However, a closer examination of the lower weight category shows that for airplanes weighing between 2000 and 2500 pounds the rate of fatality for this type of accident is relatively close (38.9 for the low-wing configuration and 32.5 percent for the high-wing configuration). The rate of fatalities for the extremely light-weight airplanes (< 2000 pounds) for this type of accident is 27 percent for the low-wing configuration and 24.4 percent for the high-wing configuration. The low fatality rate for these light-weight airplanes may

TABLE 9. SUMMARY OF ACCIDENT DATA FATALITIES TO OCCUPANTS INVOLVED BY SUBCATEGORIES AND ACCIDENT TYPES (NTSB DATA 1971 THROUGH 1973)

Subcategory (a)	Number of Accidents Surveyed	Ratio No. 2 (b), Percent			Deviation from Mean Average Value of Ratio No. 2 (c) for Category (Percent)		
		Stall	Collision with Ground	Collision with Obstacle	Stall	Collision with Ground	Collision with Obstacle
1A Low-Wing	1595	38.6	66.3	38.3	±8.5	±1.1	±15
1B High-Wing	2907	45.7	64.5	28.3			
2A Low-Wing	933	43.	56.8	35.3	±5.4	±8.5	± 1.4
2B High-Wing	1312	38.5	67.4	34.2			
4A Low-Wing	583	74.3	78.3	66.1	±2.6	±1.5	±11.5
4B High-Wing	99	70.4	80.8	83.3			

(a) See Table 4 for definition of subcategories

(b) Ratio No. 2 = (Number of fatalities/number of occupants) (for a particular accident type involving an injury and/or a fatality)

(c) Based on average of low and high-wing ratio values for each type of accident

be attributed to the lower impact speeds of these airplanes as a result of their lower flight speeds. The fatality rate associated with the agricultural airplane for this type of accident is 27.3 percent (Table 8). Since there are very few low-wing airplanes weighing less than 2000 pounds in the accident data as compared to 2000 to 2500 pound low-wing airplanes, the 38.9 percent shown in Table 9 is due to the fact that the weighted value is based on relative number of accident cases included.

- The comparison of the number of fatalities by accident types for twin-engine high-wing and low-wing airplanes is generally within $\pm$ 3 percent of their mean average except for the case of impact with an obstacle. However, the sample of this type accident in the data bank for the twin-engine high-wing airplane is inadequate for a true comparison.

Ratio No. 2 (Table 8) is used in an effort to provide a level of severity of an accident by only including accidents in which injuries occur. (Accordingly, the data does not indicate the chances of survival in accidents which do not involve injuries). This ratio indicates that "collision with the ground" consistently results, except for the agricultural airplanes, in a high fatality rate. The impact velocities associated with this type of accident are higher and will require the absorption of a greater amount of energy than that of the stall and the obstacle collision types of accidents. Although it may not be practical from weight and cost effectiveness considerations to provide crashworthiness capabilities to fully cover this type of accident, the use of a consistent crashworthy design philosophy in the design of a new airplane should provide a reduction in potential fatalities.

The results of the CAMI and NTSB data review and evaluation indicates that work should be performed to evaluate the effectiveness of incorporating shoulder harnesses along with seat and safety belt installations that are consistent with the present structural crashworthiness capabilities of each of the general aviation airplane models now in operation.

SECTION 4

MATHEMATICAL MODEL REQUIREMENTS

4.1 GENERAL AVIATION INDUSTRY COMPUTER CAPABILITIES

Seven members of the General Aviation Manufacturers Association (GAMA) were sent an inquiry regarding their current and anticipated computer capabilities. Included in the inquiry was a data sheet soliciting information regarding:

- computer manufacturer and model number
- core storage
- peripherals (tapes, discs, drums)
- systems (operating, plotting, interactive, Fortran levels)

The information was solicited from the manufacturers for the purpose of evaluating the capability of the general aviation industry to use program KRASH, modified as noted in Section 4.4, identify the types of changes that may be required in the program before it is distributed to the industry, and identify the equipment (or arrangements) required of the industry members in order to utilize KRASH to its fullest capability.

Based on the responses received from the manufacturers, the results of the survey indicate the following:

- Access to a computer with 500,000 bytes or more is, or will shortly be available for six of the companies.
- Four of the companies noted that they have 7 or 9 track tapes available for physical storage of data. However, KRASH, as presently coded, uses tapes only for plotting.

- Four of the companies stated that they have discs comparable to the TELEX 6330 model used by KRASH. The discs are an internal means of managing data.

- None of the companies have drums as part of their peripheral equipment. However, since the use of drums only increases the rate at which data is transferred, the only effect on the program will be in the area of computer run time.

- The companies have different operating systems (mostly disc operating virtual systems) than the type of system that KRASH operates on (IBM 360 Multiprogramming with a Variable number of Tasks, MVT). The operating system is internal and only reflects the manner in which the computer jobs are managed, based on peripheral usage, allocation of core, and priorities.

- Only one company has plotting capability.

- Only one company has interactive capability.

- All the companies use basic Fortran IV (F,G,H, levels)

Program KRASH currently requires 490,000 bytes of core. The program is written in basic Fortran IV, level H. It is compatible with the larger computers (CDC, IBM 360, 370), taking into consideration the normal adjustments in adapting to different operating systems. The general aviation industry is equipped to use program KRASH, as is, with the exception of the plot routine. The plot routine is most valuable in the presentation of data. Generally, unless operating in the interactive mode, the plots may not be available to the designer until a couple of days after the computer printout is received, reviewed and input data changed. Currently, the plotting routine used in KRASH is stored in core and requires approximately 20 percent of the 490,000 bytes. Deletion of the current plot routine for the general aviation industry will allow for the following two alternatives.

- Reduction in core size and, therefore, a higher run priority leading to faster turn-around time.

- Maintain the same core size and enlarge the capability to treat larger math models (masses, members), or provide additional features at a future date.

Even if the current in-core plotting routine is replaced with an out-of-core plotting routine, the problem still remains that the industry does not currently, nor plans in the near future, to have plotting capability.

The major considerations for the industry with regard to using KRASH are: (1) whether to perform analysis using in-house computer facilities or to utilize a time sharing computer, (2) to use KRASH with its maximum capability (core size, plotting), which could involve additional capital investment, or to use a limited version of the program (smaller, no plotting)

4.2 GENERAL AVIATION AIRPLANE CRASH ANALYSIS REQUIREMENTS

The review and evaluation of general aviation airplane configurations, usages, operational and structural design characteristics, accidents, industry design practices and industry computer capabilities, indicates that the use of a computerized analytical technique for performing crash analysis would be an asset to the industry if it contained certain features. The development of a general aviation airplane industry crash analysis computer program must take into consideration the need to analyze reasonably complex crash conditions, yet not impose unrealistic and costly investments in specialized manpower and/or equipment to facilitate improved future crashworthy designs.

Ideally, the computer program should have the capability to:

- Provide sufficient information which can be used to assess an occupant's chances for survival. As a minimum this information should consist of defining floor acceleration pulses and evaluating cabin damage and cabin geometry change.
- Define forces, accelerations, velocities and displacements in three directions.
- Treat multidirectional impact forces, angles and angular rates representative of the probable crash conditions associated with the different airplane usages and operational characteristics.
- Represent various types of structural behavior for a wide range of structural element types, particularly wherein post-failure large deflections occur.

- Treat structural failures and the consequences of the failures on surrounding structure.

- Represent different airplane configurations such as high-wing, low-wing, single-engine, twin-engine, tandem engines, individual and multiple seating accommodations, weights up to at least 12500 pounds, and retracted or extended landing gear.

- Provide the means to treat differences in terrain (level, hilly, water, dirt, concrete) using available data for describing the properties of the terrain.

- Treat the significant phases of multiple impact crashes wherein the effect of an initial impact is accounted for in subsequent impacts during the same crash.

- Utilize crash input acceleration magnitude, shape, duration and direction information as an input to the airplane, if available.

- Provide data as part of the analysis which can be used to assess energy flow, member stresses, and structure rupture.

- Facilitate usage and understanding of standard values, English symbols and simplified input requirements.

Furthermore, the program should be written in Fortran IV and be applicable for use on the larger size computers (i.e. IBM 360, IBM 370, CDC 6600) having at least 375,000 bytes of core storage. Plotting capability, while a potentially useful tool, can be dispensed with for the present. A plot routine should be compatible with the particular user's system, otherwise, unless all user's have "like" systems the plot routine will be superfluous.

While the description of the computer program's requirements is comprehensive, its usefulness will be inhibited unless the program is accompanied by appropriate documentation. As a minimum the documentation should consist of a User's Manual describing the theory, input-output requirements, a sample illustrative problem, techniques for representing structure, instructions on how to utilize specialized features, program limitations, and structural design guidelines.

4.3 PROGRAM KRASH

Program KRASH was developed for the purpose of providing a practical engineering analytical approach to determine the crashworthiness capabilities

of vehicles.

The digital computer program KRASH predicts the response of vehicles to multidirectional crash environments. The program computes the time histories of N interconnected masses. Each mass is allowed six degrees of freedom defined by inertial coordinates x_i, y_i, z_i, and Eulerian angles ϕ_i, θ_i, Ψ_i, where $i = 1, 2 \ldots N$. Euler's equations of motion are written for each mass. The equations of motion are integrated numerically to obtain velocities, displacements and rotations. Gravity forces, internal forces and moments, and external forces are computed. For small deflections a linear analysis is followed, and for large deflections general plastic deformation is allowed. The program provides for unloading and subsequent reloading along a linear elastic line.

A succinct description of program KRASH and the techniques it applies are presented in Reference 14, along with the experimental data obtained during a fully instrumented, full scale vehicle drop test with which the capability of the program was successfully verified. The essential features of program KRASH are:

(a) The program is designed to provide sufficiently accurate data from which an assessment can be made of the occupant's chances of survival in a crash environment.

(b) The formulation takes into consideration that the load-deflection behavior of a structure can be approximated using good engineering judgement so as to provide sufficiently accurate responses for the intended use.

(c) The analysis is premised on the fact that only a portion of the major structural elements (and these can be readily identified) need be modeled in the post-failure region.

(d) The program employs stiffness reduction factors (KR's) which are a method by which the linear stiffness of each structural element can be modified to treat nonlinear behavior.

Program KRASH's formulation is consistent with the amount and quality of detailed data that is available during a preliminary design study. Furthermore, analyses during preliminary design studies can serve to:

- ascertain critical design regions wherein alterations to the structural response will be most beneficial,

- determine the extent to which additional energy absorption is needed, and

- determine the structural element load-deflection characteristics and, consequently, structural design and size requirements that are needed to meet a specified or desired crashworthiness capability.

Prior to the initiation of the study, program KRASH had the capability to:

- Define a six-degree-of-freedom (DOF) response at each representative location, including three translations and three rotations (accelerations, velocities, and displacements are computed).

- Determine mass accelerations, velocities and displacements, and internal member loads and deformations at each time interval.

- Provide for general nonlinear stiffness properties in the plastic regime, including different types of load-limiting devices, and determine the amount of permanent deformation.

- Determine how and when rupture of an element takes place and redistribute its load-carrying capability over the other structural elements involved.

- Define mass penetration into an occupiable volume.

- Provide for ground contact by external structure including sliding friction.

- Include viscous damped internal elements.

- Include a measure of injury potential to the occupants; for instance, the probability of spinal injury indicated by the Dynamic Response Index (DRI).

- Determine the distribution of kinetic and potential energy by mass item, the distribution of strain and damping energy by element, and the crushing energy associated with each external spring.

- Determine the vehicle response to an initial condition that includes linear and angular velocity about three axes and any arbitrary vehicle attitude.

- Treat up to 80 masses (480 DOF), 100 internal (6 x 6) beam elements and provide plots of the responses.

A comprehensive description of KRASH prior to this program is presented in References 3 and 4. Changes to KRASH related to this program are described in Section 4.4. A complete description of KRASH updated for the general aviation airplane industry is presented in the User's Manual and Structural Design Guide (Reference 13).

4.4 MODIFICATIONS TO KRASH

The requirements of a computer program to meet the needs of the general aviation industry were evaluated both with regard to KRASH's capability, as developed previously, as well as to the modifications that could be incorporated to extend the program's capability and yet be consistent with the philosophy under which KRASH was developed, which is to be a practical preliminary design tool. Program KRASH, as originally developed, meets many of the requirements necessary to perform crash analysis of general aviation airplanes. To comply with the overall requirements and to facilitate KRASH's usage by the industry, several modifications are incorporated. Since a comprehensive discussion of each modification is contained in Section 1 of the User's Manual (Reference 13) a brief description of each is presented in the following paragraphs.

4.4.1 Generalized Impact Surface Capability

This modification allows the user to specify a surface which makes an angle with the horizontal of up to 90 degrees. The airplane represented by the math model can be positioned relative to the surface with the proper input data selection, or, if the user chooses, the program will automatically position the vehicle in the proper attitude relative to the surface using the existing external spring input data. This is a practical feature and requires only one additional input term, the angle of the slope. The generalized impact surface is applied in the analysis of a stall-spin crash test that impacts into a 45 degree slope which is described in Section 5. The generalized surface capability is useful for analyzing crash conditions involving hillsides, mounds and possibly trees.

4.4.2 Cabin Volume Change

The prime concern in a crash is the protection of the occupant. As is noted earlier, one of the design goals is to have the structure crush and deform in such a manner that a liveable cabin volume will be maintained for the occupant and that the occupant is kept from impacting structure or hardware in such a manner as to receive serious or fatal injuries. Consequently, coding is added to KRASH wherein any eight masses are specified for a particular volume. The original coordinate positions of the masses are used to compute an initial volume. The new coordinates of the specified masses are computed at each integration. The ratio of the new volume to the original volume is calculated and printed out along with the regular output print. Although usually only one volume (occupiable region) is of concern, the program allows the user to specify up to eight distinct volumes. This modification in no way alters the program's basic computations. Since there will be an occupant-seat-restraint system model available later in the program, a refinement for future consideration would involve combining the volume history from KRASH and the occupant model history to ascertain relative positions and velocities of the structure and occupant extremities.

4.4.3 Acceleration Pulse Input

KRASH is modified to include provisions for specifying an acceleration pulse magnitude, shape, duration and direction for as many as 50 mass-directions*. The program requires that the following information be defined:

- location of pulse (which masses)
- direction of pulse (one or more of six directions)
- history of the acceleration at the specified mass and its direction

Once specified, the accelerations of the designated masses are prescribed in the subroutine where accelerations are normally computed so that system velocities, displacements and subsequent forces are computed thereafter. Generally, a crash analysis is initiated with a known set of impact velocities. The velocity at each mass point is integrated to obtain a

* Each mass can have accelerations acting in six directions.

displacement. The displacement is used to develop forces via external force-deflection curves and internal member stiffnesses. However, this routine makes it possible to excite the system with an acceleration. It may be most useful in modeling substructure (seat system) or where an impact can be idealized with an acceleration pulse, (i.e. water impact).

4.4.4 Internal Computation of Element Linear Stiffnesses

The internal computation of element linear stiffnesses involves providing the following input data for each member:

E = modulus of elasticity

G = shear modulus

J = polar moment of inertia

A = cross sectional area

L = member length

I_y, I_z = area moment of inertia about the y and z axis

The data is used in the program to formulate a 6 x 6 linear stiffness matrix for each element. One line (card) of input data per internal element member is required instead of six cards of stiffness terms as was formerly required. Since stiffnesses are often obtained from the member properties prior to input to the program, this change can result in a substantial saving in effort. Wherein stiffnesses are known from available data, material properties representative of the section can still be readily obtained since the beam stiffness terms are related to the member properties in a relatively straightforward manner. The formulation of linear stiffness within the program does not alter any of the basic computations. Direct input of the stiffness matrices is still available as an option.

4.4.5 Member Directional Stresses

The determination of member directional stresses is obtained using the material property data used by the program to computer linear stiffnesses. The computation of stresses is an option which can be used even for

members wherein direct input of the stiffness matrix is employed. When stresses are desired, the program requires that the members be identified and that, in addition to the member properties used to formulate element stiffnesses, the respective distances to the neutral axis of the element and appropriate yield stress be provided. The procedure the program follows to compute stresses with the required input data is as follows.

- Using member forces computed in the program and the member properties, the element stresses acting at the top, bottom, right and left side on each of the selected members is determined. The method of calculating the member forces is unchanged; stresses are calculated only for output information and are not used internally in the force calculations.

- Combined stresses due to bending, axial, shear and torsional forces are computed.

- The principal and maximum shear stresses are computed.

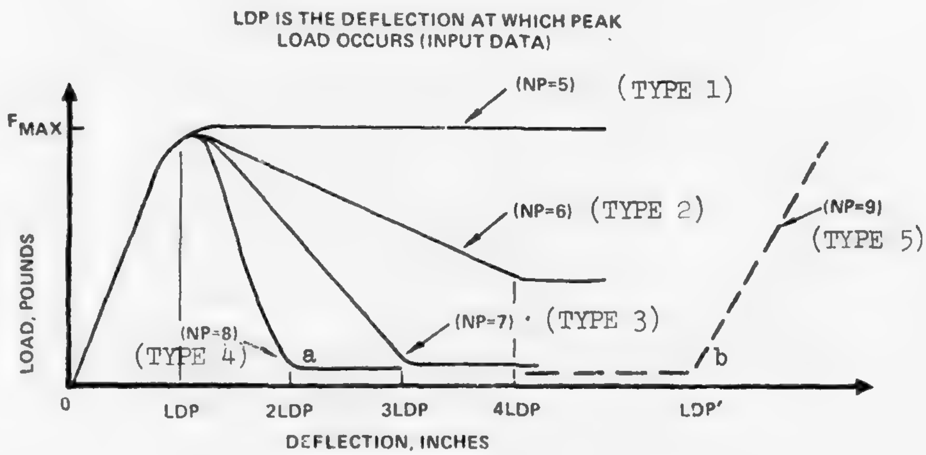
- The maximum shear failure theory and the theory of constant energy of distortion for a combined axial and shear stress condition are applied.

- Ratios of element stress to yield stress are computed during the entire analysis (A ratio of >1.0 indicates yield has been exceeded)

The above approach is simple and consistent with the techniques utilized in KRASH and, as such, has limitations. The incorporation of the stress check offers the advantage of being able to monitor selected elements to determine if they have reached a yield condition. Once the element has yielded the failure theories are invalid and, consequently, the most meaningful use of the stress data is to identify which elements yield and at what time during the crash analysis. The stress data can help assess the validity of results with regard to the data used in modeling some of the structure. However, the computed stresses should not be used to verify structural designs because they do not provide sufficiently accurate data with which to make critical design decisions. For example, the effect of stress concentrations, unique geometry shapes and detail attachment practices at joints, are not included. Furthermore, care should be exercized in using this option since many times a complex structure is idealized with beam properties.

4.4.6 Internal Computation of Nonlinear Curves

The determination of the exact nonlinear behavior of structural elements is very difficult, particularly when interaction of loads is involved. By the use of linear stiffness reduction curves, KR, different types of nonlinear behavior can be represented. It is shown in Reference 4 that by approximating the nonlinear behavior in this manner, while representing the proper failure load, responses which are sufficiently accurate for crash analysis purposes are obtained. Thus, carrying this approach one step further by preprogramming the typical nonlinear curve shapes, as shown in the following sketch, the need to input all KR tables is obviated.



A type 1 curve	uses	five data points	(NP=5)*
A type 2 curve	uses	six data points	(NP=6)*
A type 3 curve	uses	seven data points	(NP=7)*
A type 4 curve	uses	eight data points	(NP=8)*
A type 5 curve	uses	nine data points	(NP=9)*

The input requirements to use the nonlinear curves consist of the identification of the member for which nonlinear behavior is desired, the deflection (LDP) at which inelastic behavior occurs, the direction of interest (3 translation and 3 rotations are possible), and the number of points (NP)

* Coding is self contained in KRASH

defining the curve. When NP = 5, 6, 7 or 8 or 9, the program computes the nonlinear curve. When a 9 point curve is used the user also specifies the deflection corresponding to point b in the above sketch. When NP ≥ 10 a series of KR versus deflection data points is required. This allows the user to retain the capability to define an arbitrary load-deflection curve. The relationship between KR versus deflection and load versus deflection is defined in the User's Manual (Reference 13, Section 3).

4.4.7 Provisions for Modeling Earth Scooping and Plowing

This modification is applied only to the masses which are identified as having an external spring. Following the principles outlined in Reference 12, the average scoop force acting on the airplane can be determined and approximated using a trapezoidal force-time history. Plow forces are computed in the same routine wherein crash forces and energies are obtained. Usage of this routine requires an input of average force at the appropriate mass location where scooping takes place.

4.4.8 Standardization of Terms

The purpose of using standardized terms is to simplify the input requirements for the user. Several areas where standardization is incorporated into program KRASH are described in Reference 4. The use of internally coded KR curves in this program is another example of standardization. The manner in which member damping is input into the program is altered to give the user more flexibility. The original version of KRASH requires one card of input data for each member. Thus, representing percent of critical damping for the particular member could require a maximum of 120 cards. KRASH is now coded that all members have a standard one (1) percent of critical damping. The user can use this standard value, give all members a different value, or give the members any combination of damping values. It is possible to run a 120 member analysis with as little as 1 damping card, instead of 120 damping cards.

4.4.9 Refinement of Damping Force Formulation

This change recodes the manner in which rotational velocities are

calculated which lead to the damping forces. Previously, negative damping terms could be developed which could hinder the analysis. Now, with judicious selection of damping coefficients and integration interval, this should no longer be a problem.

4.4.10 Addition of 'Model Parameter Data' Printout

This change provides a printout of vehicle c.g. coordinates, mass and inertia properties, member frequencies, and damping terms. This printout is valuable in the initial checkout of the math model to ascertain that the math model properly represents the vehicle properties. It also allows the user to detect any potential instability problem which could be associated with high frequencies or large damping terms.

4.4.11 Treatment of Beam Longitudinal Elongation

The manner in which the program treats beam longitudinal elongation due to large lateral translations and rotations is improved. The program previously utilized a method which led to inaccurate axial deflections under conditions of large lateral deflections or beam rotations. Now the current overall beam length is calculated, and incremental axial deflections are based on differences in beam lengths from one integration interval to the next.

4.4.12 Addition of External Spring Force and Compression Data

The program now prints out the external spring forces along with the spring compression in both ground and mass axis coordinates. The directions in which the forces act are identified. The added external spring force data is conveniently located with the external spring deflection data and provides useful information to help the user assess the results. The data allows the user to distinguish between crushing and friction forces.

4.4.13 Separation of Crushing and Friction Energy

The program now separates the crushing and friction energy terms. Previously both were included under the heading "crushing energy". The user can now assess the relative effect of the structure crushing and ground

friction employed in the analysis.

4.14.14 Revision to the KR Function Usage

The manner in which the KR function is used in the program has been revised. This change does not effect the input of data. The linear forces are multiplied by KR's to obtain reduced forces. Previously, the KR's reduced the linear deflections which, in turn, were multiplied by a linear stiffness matrix to obtain the reduced forces. The program is now coded such that, for the normally coupled beam motions (z, θ and y, φ), the proportions of the total force and the moment due to deflection and rotation inherent in the linear system are preserved, while still accounting for the nonlinear load-deflection characteristics. It is desirable to retain this relationship in order to minimize the possibility of developing negative strain energy with large nonlinear responses.

4.14.15 Revisions to the Input Format

This change simplifies the data input requirements and organizes the print of data in a more orderly fashion. The data that is normally required (basic data) is now input initially in the following sequence:

- control cards
- mass coordinates and associated data
- external member data
- internal member data
- options (volume, stress, DRI)
- seldom used data (Euler angles, inertia cross products)

Section 2 of the KRASH User's Manual (Reference 13) describes and illustrates tne revised impact format.

4.4.16 Revisions to the Output Format

This change organizes the output data in a more orderly manner and provides additional information to facilitate the user's understanding and

evaluation of the results. Included in this change are the following:

- The print-out of the input data is presented in a more organized manner such that standard mass and member data is easily delineated.
- The unnecessary presentation of large zero matrices of data is eliminated.
- The output data provides a print of member strain force and total forces. Previously only the member strain force was available. The difference between member total force and member strain force is the damping force contribution. Consequently, the user can assess the relative effect of the stiffness and damping data that contributes to these forces.
- The output format contains expanded print for external spring forces and deflections which now includes ground contact point loads in ground (or slope) and mass axes.
- Vehicle c.g. translational velocities in ground axes, based on system linear momentum considerations are presented at each print interval.

4.4.17 <u>Miscellaneous Coding Changes</u>

The program has been recoded to allow the use of large initial pitch angles (>90 degrees), and to properly calculate forces resulting from negative external spring lengths (required for the inverted crash condition). This change eliminates the possibility of computing negative crushing energy.

The program has also been recoded to allow external springs to deflect beyond the maximum free length value that may be used as an input. This change eliminates one of the conditions which could result in negative external spring energy being developed in a math model.

4.4.18 <u>Addition of Subroutine ECHO</u>

This subroutine was added to the program to facilitate the user's task of evaluating the validity of the input data format. ECHO prints out the input in card image format which allows for a rapid assessment of any potential errors in data, input format, out of order cards and/or improper control cards.

4.4.19 Use of English Words

English words have been added in such a manner that they precede the printed symbols, which are retained. The English words clarify the meaning of the output while the symbols in many instances relate to the coding contained in the program.

SECTION 5

ASSESSMENT OF PROGRAM KRASH

5.1 PURPOSE AND METHOD

Program KRASH was verified using experimental data obtained from a full scale helicopter crash test involving a combined vertical and lateral impact velocity(Reference 3). There are many similarities in the requirements for the crash analysis of helicopters and general aviation airplanes, including:

- o exposure to multidirectional forces during a crash
- o comparable takeoff weights for certain classes of each
- o similar structure in many areas
- o multiple impacts for certain crash conditions
- o comparable crash durations

However, airplanes and helicopters have significant differences which affect the requirements for performing crash analysis. These differences involve:

- o design configurations
- o mass locations
- o seat systems
- o operational modes which will affect probable impact conditions

Furthermore, the results of the evaluation of airplane design characteristics, as well as the accident review and evaluation, led to the inclusion of additional capability for KRASH (discussed in previous section). Consequently, the development of KRASH, modified for general aviation airplane application, requires that some reasonable assessment of its capability be made prior to initiating fully instrumented full scale airplane crash tests in support of

the verification program of Task II.

Ideally, it is desirable to compare analytical results with controlled crash test data from test articles of comparable size, configuration, complexity and weight as the intended structural system. The availability of such test data for two different general aviation airplanes of current design and representing two probable accident conditions, provides a practical means of assessing program KRASH. The crash tests, while limited in the amount of measured quantitative structural response data, provided a significant quantity of high speed film and photographic coverage with which to assess KRASH's capability to predict structural deformation, multiple impacts and rigid-body large motion post-impact behavior. The tests also provide data with which to assess the validity of program modifications and to obtain information which can be utilized in the development of a KRASH User's Manual and Structural Design Guide (Reference 13). The crash tests represent impact conditions for typical general aviation airplane crashes in which multidirectional forces are involved. The mathematical models, crash test data, comparison of analysis and test results, and the assessment of KRASH are described in the following subsections.

5.2 GENERAL DESCRIPTION OF AIRPLANES

To demonstrate that program KRASH is potentially an acceptable analytical method with which to perform crash analysis for general aviation airplanes, two representative airplanes are selected to be modeled and the results of the analyses compared to the available test data. The airplanes designated Airplane A and Airplane B are shown in Figures 14 and 15 and are described below:

Airplane A

- Category 1 (See Table 4)
- single-engine, high-wing configuration
- side by side seats (2 occupants)

Figure 14. Airplane A, High-Wing Single-Engine Type

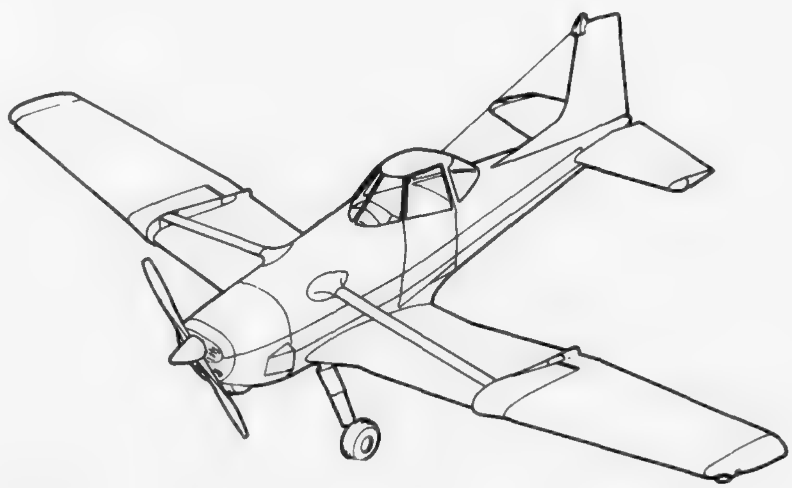


Figure 15. Airplane B, Low-Wing Single-Engine Type

Airplane A (Cont.)

- o used for training, sport and aerobatic (acrobatic) purposes
- o stall speed ≤ 42 knots
- o cruise speed (75 percent power) ≤ 102 knots
- o maximum takeoff weight, 1600 pounds
- o fuselage is of all semi-monocoque construction. The wing is a cantilever structure designed with two main spars and with a midspan braced strut. The landing gear is a non-retractable tricycle type. The tail is of cantilever design.
- o flight design load factors of: +4.4 g's and -1.76 g's (utility)
  +6.0 g's and -3.00 g's (aerobatic)
- o overall dimensions are: wing span = 384 inches, length = 280 inches
- o the weight - c.g. envelope is shown in Figure 16

Airplane B

- o Category 3 (see Table 4)
- o single-engine, low-wing configuration
- o single seat
- o used for application of chemicals to or seeding crops
- o stall speed ≤ 50 knots
- o cruise speed (75 percent power) ≤ 122 knots
- o maximum takeoff weight = 3300 pounds (4000 pounds in restricted category)
- o Fuselage structure is a rectangular section, welded steel tube construction in the forward and cabin area and semi-monocoque construction in the rear. The wing is a cantilever structure designed with two main spars with a midspan braced strut. The landing gear is a non-retractable tail-wheel type. The tail is of cantilever design.
- o flight design load factors of: +3.8 g's and -1.52 g's
- o overall dimensions are: wing span = 474 inches, length = 273 inches
- o the weight-c.g. envelope is shown in Figure 17

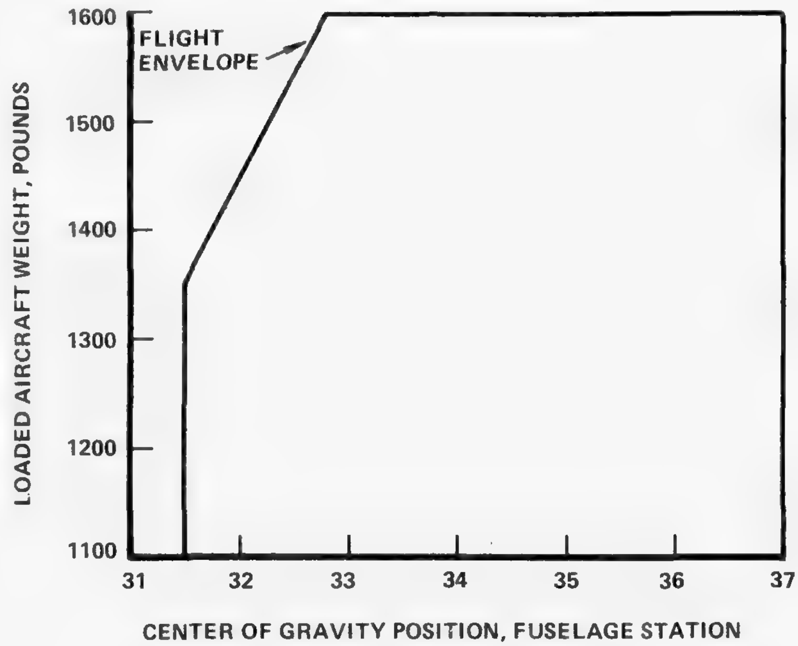


Figure 16. Weight - CG Flight Envelope for Airplane A

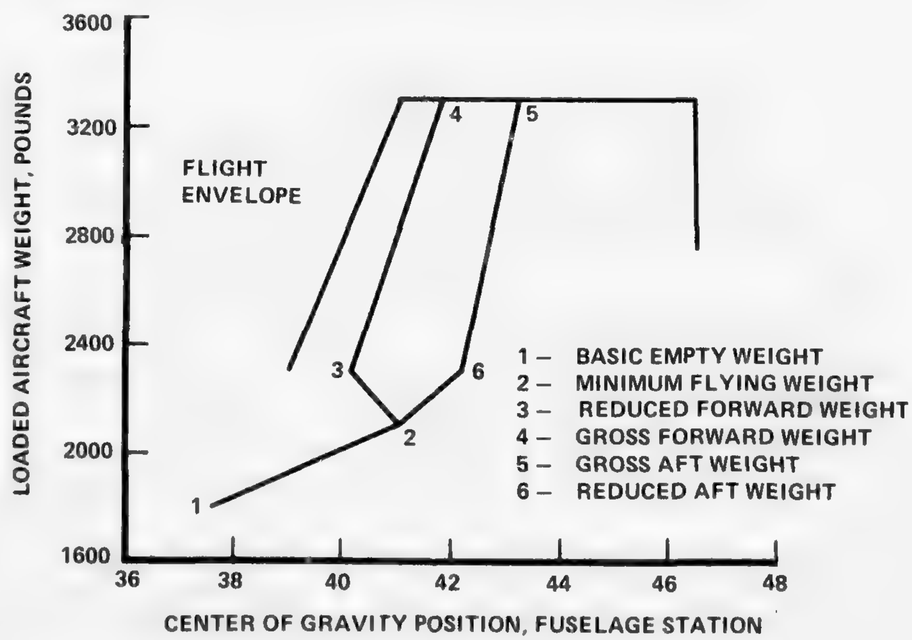


Figure 17. Weight - CG Flight Envelope for Airplane B

5.3 CRASH TEST DATA

5.3.1 Airplane A Stall-Spin Crash Test

5.3.1.1 Test Objectives

The test objectives were to:

- check out the crash test facility and determine potential improvements for further tests
- determine crash characteristics of the Category 1 airplane during a stall-spin crash
- determine the chances of survival for the occupants during a stall-spin crash

This was the first full scale airplane crash test performed at a test site which consists of an asphalt track 20 feet wide and 600 feet long terminating in a dirt barrier that is readily shaped to simulate selected crash impact angles. A steel rail in the center of the track is used for control of the tow dolly during acceleration of the specimen. Propulsion is provided by an engine and winch applying direct power to the specimen tow dolly through a steel cable.

5.3.1.2 Test Setup and Procedure

The test specimen contained two instrumented dummies as occupants (95th percentile (pilot) and 50th percentile (co-pilot)). The accelerometers in the dummies were located at F.S. 44.0, W.L. -16.0, B.L. ±9.0 in the pelvises. and F.S. 48.0, W.L. +19.0, B.L. 9.0 for the pilot head and F.S. 47.0, W.L. +17.0, B.L. -9.0 for the co-pilot head. Accelerometers were located on the centerline of the floorboard (F.S. 56.7, W.L.-11.0, B.L. 0.0) and oriented in the vertical and longitudinal directions. One wing had lead secured in the fuel tank bay and the other fuel tank was filled with colored water representative of the fuel weight. Angular spoilers were attached to the leading edge upper surface of each wing to prevent lift off. The instrument panel was representative of the panel normally used in this particular airplane. The seats were standard 1969 versions. The left seat had the regular seat belt but the right seat restraint system included a seat belt, shoulder harness and attachments. The nose wheel was replaced with a wheel and dolly.

AD-A032 415 LOCKHEED-CALIFORNIA CO BURBANK F/G 1/2
A METHOD OF ANALYSIS FOR GENERAL AVIATION AIRPLANE STRUCTURAL C--ETC(U)
SEP 76 G WITTLIN, M A GAMON DOT-FA75WA-3707
UNCLASSIFIED LR-27698 FAA-RD-76-123 NL

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The dolly and tow attachment incorporated a mechanical release system which caused both the dolly and tow cable to release simultaneously. A 'dead man' brake system consisting of an accumulator and solenoid valve connected directly to the ship's battery was installed. One 47 frame/second camera filmed the overall crash. One 64 frame/second camera with telephoto lens filmed the impact with the barrier. One 1000 frame/second camera filmed a close-up of the barrier impact (the poor lighting provided for this camera made the results unusable for engineering analysis). Two normal speed (18 frames/second) documentary cameras filmed the overall crash. Figure 18 shows a side view of the airplane in position prior to impacting the barrier with a velocity of 45 feet/second.

5.3.1.3 Crash Sequence

The nose wheel makes initial contact with the dirt barrier. Failure of the nose wheel strut aft does not significantly impede the forward motion of the airplane and the spinner and lower portion of the engine cowl contact the barrier approximately 30 milliseconds later, with a forward velocity of approximately 45 ft/sec. The forward fuselage, after impacting the barrier, rides up as high as three feet. The tail cone buckles at its attachment to the fuselage aft bulkhead at approximately 100 milliseconds after spinner impact. The co-pilot, who was restrained with a shoulder harness, appears to move forward and nearly impacts the instrument panel with his head at approximately 140 milliseconds after spinner impact. The co-pilot impacted the control wheel and his lower extremities impacted the instrument panel. The pilot apparently submarined under his lap belt (he did not have a shoulder harness) and impacted the control wheel with sufficient force to break the left grip of the wheel. Figure 19 shows a side view of the airplane in its post crash condition. Figure 20 depicts the crash sequence from approximately nose (spinner) impact to 180 milliseconds thereafter. The film analysis was performed during this program. The film analysis data and results are provided in Appendix C. The 47 frame/second film was used for the analysis, which is approximately 20 milliseconds per frame. Consequently, the sequence shown in Figure 20 may be delayed by up

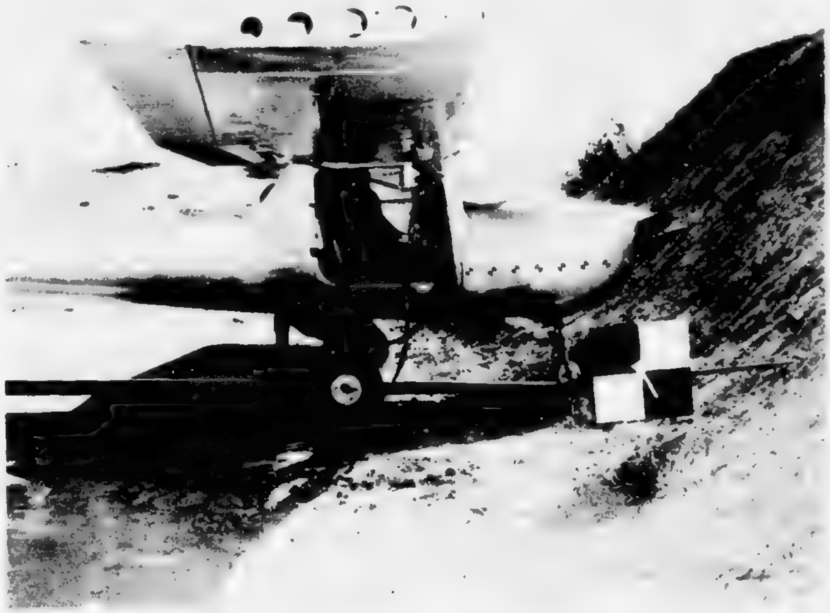


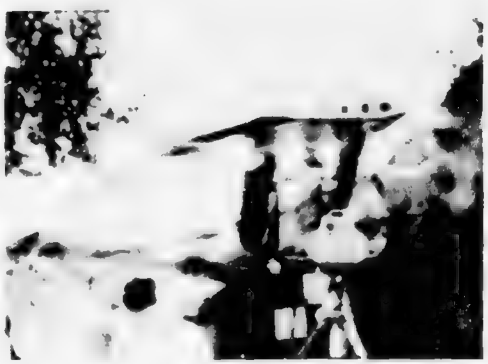
Figure 18. Side View of Airplane A Prior to Crash Test

Figure 19. Side View of Airplane A After the Crash Test

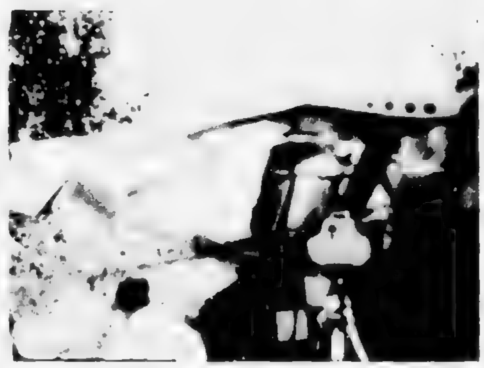
Time = 0

Time = .020 Seconds

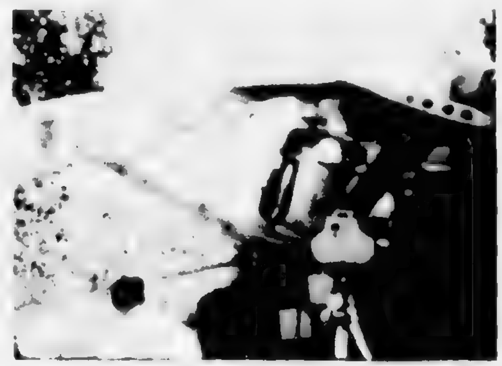
Time = .060 Seconds



Time = .100 Seconds



Time = .140 Seconds



Time = .180 Seconds

Figure 20. Crash Test Sequence for Airplane A

to 20 milliseconds if the event noted at time zero is due to nose gear failure and not spinner impact.

5.3.1.4 Test Results

As a result of the test crash, the airplane sustained the following damage:

- o Failure of the left wing rear spar attachment (this was not a standard part)
- o Failure of the right door post
- o Buckling (aft) of the nose wheel strut
- o Buckling of the engine mounts
- o Buckling of the firewall
- o Bending of the control column and wheel
- o Denting of the nose cap
- o Wedging of the rudder to the full right position

There was no damage to the main gears, seats, occupant restraints and fuel system.

The summary of recorded accelerations is given below:

Accelerometer * Location	Peak g's
Floorboard over the main gear	
o longitudinal	121
o vertical	106
Pilot head vertical	100
Co-pilot head vertical	104
Pilot pelvis vertical	94
Co-pilot head longitudinal	113

* Presented in airplane coordinate system for the structure and body axis (see Figure 1-4, Reference 12) for the occupants

A composite of all the accelerometer traces indicated that the peak amplitudes all occurred simultaneously and they have approximately the same levels and waveforms. From past experience, there is a time lag between the fuselage and occupant responses as well as significant differences in response frequency which indicates that the data may be deficient. Only the floor response data was used to compare with KRASH results. The occupant response data is more applicable to occupant-seat-restraint system models.

Figure 21 shows the forward fuselage damage, consisting of extensive crushing of the lower cowl, some deformation of the propeller spinner and very little damage to the upper cowl. The upper structure aft of the firewall failed in compression. The lower structure moved aft relative to the wing and upper structure. The lower fuselage structure has substantially less deformation than the upper structure. Figure 22 shows the cabin damage. The occupant (right side) with the seat belt and shoulder harness is restrained. Unlike the other occupant, he did not submarine. The volume change shown is less than the maximum distortion that occurred during the crash. The structure sprang back from 25 to 50 percent from its maximum deflected position, which is consistent with data reported in Reference 4 and findings by NASA. Analysis of the high speed camera data was performed during this program and the cabin volume behavior which was obtained is described in Section 5.5. Figure 23, which is a top view of the engine, shows the upper engine mounts in a buckled condition. The generator at the top aft portion impacted the severely buckled firewall. Figure 24 illustrates the buckled lower engine mounts and aft bent nose wheel strut. The top engine and nose strut support structure has been cut to allow access to the structure. Figure 25 shows the tail cone bending failure. Figure 26 shows the non-standard wing spar attachment shear failure described earlier. Unlike the cabin and fuselage damage, the failure of the tail cone and wing spar attachment did not pose a threat to the survivability of the occupants.

Figure 21. Three-quarter View of Forward Section Damage (Airplane A)

Figure 22. Side View of Cabin Damage (Airplane A)

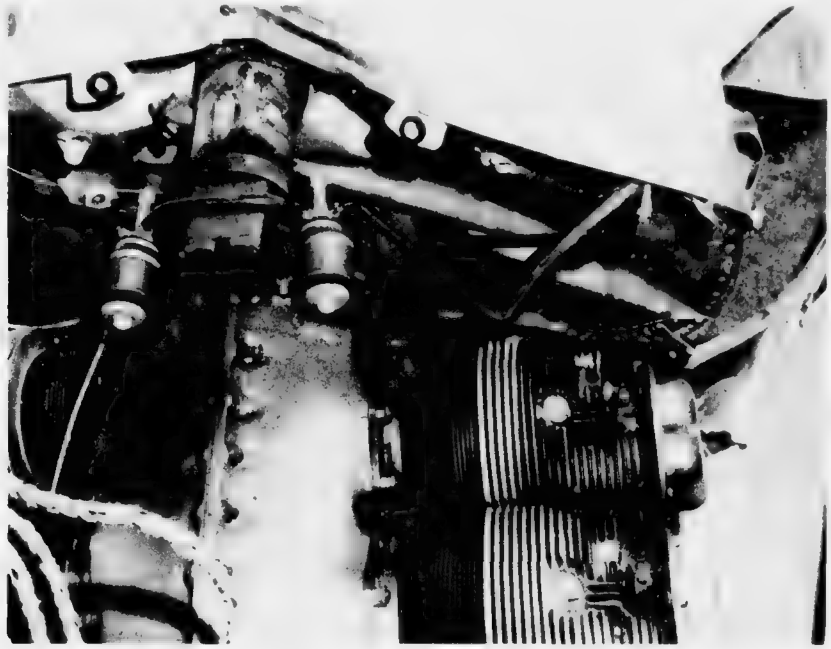


Figure 23. Top View of Engine Mount Damage (Airplane A)

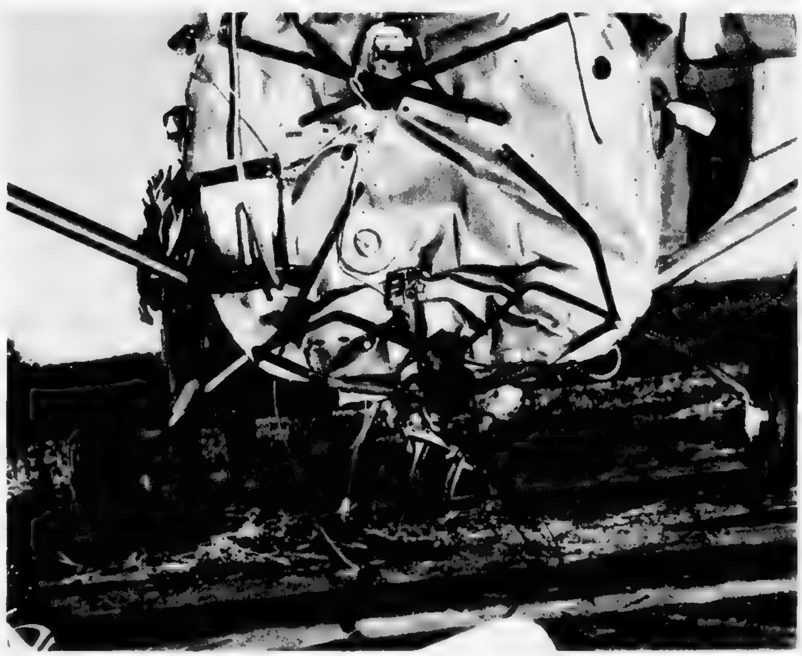


Figure 24. Front View of Engine Mount and Firewall Damage (Airplane A)

Figure 25. Side View of Tail Cone Damage (Airplane A)

Figure 26. Front View of Wing Damage (Airplane A)

5.3.2 Airplane B Turnover Crash Test

5.3.2.1 Test Objectives

The test objectives were to:

- o determine chances of survivability for the occupant during a turnover accident
- o determine acceleration levels on the structure and on the occupant during a turnover accident

The turnover test was performed at the same test facility that the stall-spin test (Airplane A) was conducted.

5.3.2.2 Test Setup and Procedure

The test specimen was an original engineering prototype and contained one 95th percentile instrumented dummy as an occupant. Accelerometers, oriented longitudinally and vertically, were located in the head of the dummy (F.S. 103, W.L. +50, B.L. 0.0) and on the structure near the airplane intermediate c.g. position (F.S. 41, W.L. +2.0, B.L. 19.0). Accelerometers were also located in a vertical position on the aft turnover structure (F.S. 110, W.L. 45.8, B.L. 0.0) and on the forward turnover structure (F.S. 84.6, W.L. 47.3, B.L. 0.0). The aircraft hopper was empty and the fuel tank was filled with 40 gallons of water (8.34 lbs/gal). The water added an additional load of 99 pounds in excess of the normal weight of fuel. The seat and restraint system for the airplane were standard for this type of airplane. The restraint system included a standard shoulder harness with a rolled lap belt to accommodate load cells. The load cells were located on the left and right hand sides of both the lap belt and shoulder harness. The instrument panel contained a full complement of instruments.

Batteries were installed in the airplane to power a wing (left side) mounted 1000 frame/second camera which filmed the occupant and cabin during the crash. Another camera operating at 1000 frames/second filmed the test run from a stationary position outside the airplane. Cameras operating at speeds of 24 frames/second and 64 frames/second were used to record the total

test run and monitor the turnover.

The airplane was accelerated by a tow engine to approximately 30.5 mph through a distance of 75 feet. The airplane was attached to the tow dolly system at the front wheels to enable the airplane to be towed along a straight line. A rear support dolly was provided to keep the tail of the airplane from descending during the tow phase of the test, thereby simulating a wheel landing condition. At a distance of 1 foot from the barrier, the airplane was disengaged from the tow dollies and proceeded as a free body.

The wheel brake system employed was the standard airplane brakes except for the replacement of the master cylinder with a 'dead man' system, consisting of an accumulator and a solenoid valve which was plumbed directly into the wheel brakes.

To accomplish a turnover, the brakes on the airplane were locked and the tow engine stopped for the final 28 feet to the barrier; the resulting drag load acting at the wheels caused the airplane to rotate nose down approximately 32.5 degrees from its towed position. After nose contact with the ground, the airplane did a complete turnover and came to rest in an inverted position. To simulate a field condition impact, the track was covered with 12 inches of dirt.

Prior to the actual test, several runs were made for the purpose of calibration. During the first calibration run, the tail of the airplane inadvertently rotated upwards caused by excessive cable slack. This mishap resulted in damage to the skin of the lower center of the tailcone. Calibration runs were used to determine starting distance from the barrier, brake application distance from the barrier, dead time and skid distance during braking, and linear velocities. During the first test run, the brake system failed and the airplane impacted the barrier. The main landing gear sheared off but there was no other structural damage. On another test run, the velocity was insufficient to result in a complete turnover. As a consequence of this aborted attempt, the engine mount assembly failed and had to be

welded before testing resumed. The test was accomplished finally with no further difficulties. Figure 27 shows the airplane test setup prior to the turnover.

5.3.2.3 Crash Sequence

Film analysis of the test indicates that the airplane forward cowl section initially contacts the ground with the following impact conditions:

c.g. velocity (ground axis)	
vertical	19.5 inches/second (down)
longitudinal	259 inches/second (forward)
pitch attitude	38.5 degrees (nose down)
pitch rate	106 degrees/second (nose down)

The film analysis shows that it takes approximately 1.5 seconds after initial nose impact for the airplane to pitch over and impact on the forward turnover structure. When the airplane is in its inverted position, it contacts the ground under the following conditions:

c.g. velocity (ground axis)	
vertical	102 inches/second (down)
longitudinal	45.5 inches/second (forward)
pitch attitude	19.6 degrees (nose down in inverted position)
Pitch rate	89.4 degrees/second (nose down in inverted position)

After the initial impact and prior to the second impact, the left wing made contact with the ground. The damage to the wing tip due to this contact is slight and the effect on the response of the fuselage, cabin structure and occupant is considered insignificant. After turning over onto the forward turnover structure, the airplane continues its nose-over motion and the vertical tail section contacts the ground before the airplane comes to rest. Figure 28 shows the airplane in its inverted position after the crash.

Figure 27. Side View of Airplane B Prior to the Crash Test

Figure 28. Side View of Airplane B After the Crash Test

Figure 29 shows the crash sequence from nose impact to 1.5 seconds thereafter. Data obtained from the film analysis is presented in Appendix C.

5.3.2.4 Test Results

As a result of the turnover crash test, the airplane sustained the following damage:

- o Failure of the forward turnover structure (downward approximately 2.5 inches)
- o Minor damage to the vertical tail section
- o Minor damage to the left wing tip and leading edge
- o Failure of the left engine mount in shear or tension at a position between the mount assembly and engine
- o Failure of the tubular mount assembly on the left side (location of failure is at the position where failure occurred during a test run and the structure was welded)
- o Extensive skin damage to the cowling and hopper area
- o Minor damage to the firewall

There was no damage to the main gears, tailcone, aft turnover structure, seat and restraint system, right wing, and right engine mounts and assembly. Based on the acceleration levels, tolerance curves and severity index analysis, the occupant was not expected to have experienced any brain or vertabrae injury.

The peak response data is summarized as follows:

Accelerometer Location*	Peak Load or g's
Pilot's Head	
vertical	32.9 g's
longitudinal	20.1 g's
Proximity of Longitudinal C.G. Position	
vertical	21.24 g's
longitudinal	11.81 g's

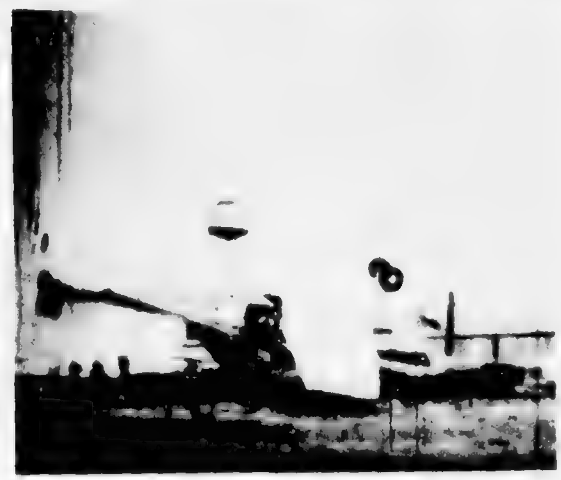
* Presented in the airplane coordinate system for the structure and body axis (see Figure 1-4, Reference 12) for the occupant

TIME = 0.0 SECONDS

TIME = .083 SECONDS

TIME = .666 SECONDS

TIME = 1.25 SECONDS



TIME = 1.50 SECONDS

Figure 29. Crash Test Sequence for Airplane B

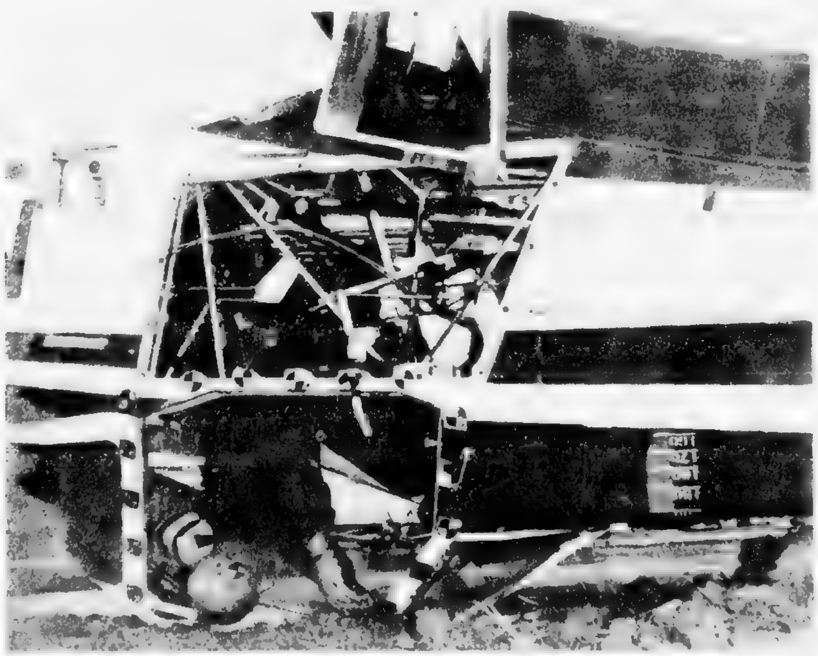
Accelerometer Location* (Cont.)	Peak Load or g's (Cont.)
Fwd. Turnover Structure Vertical	97.2 g's
Aft Turnover Structure Vertical	72.2 g's
Right Seat Belt (rolled)	399 lbs.
Left Seat Belt (rolled)	699 lbs.
Right Shoulder Harness	792 lbs.
Left Shoulder Harness	521 lbs.

During the test, the tape recorder malfunctioned causing a loss of definition of the response wave forms and times of occurrence of the peak accelerations and loads. While seat belt and harness load cell data may be useful in future evaluation of occupant-seat-restraint system models, the structural acceleration measurements were of little value in assessing KRASH.

Figure 30 shows a side view of the forward fuselage damage. Although the cowl is substantially deformed, the structure at the firewall and aft of it experienced little or no damage. The damage to the underside of the cowl was experienced during the preliminary tests. Figure 31 shows the pilot position after the crash. The forward turnover structure has been compressed and is buried in the dirt while the aft turnover structure had no noticeable damage. The structure surrounding the cabin and below it appears to have remained unchanged which indicates that the energy associated with the impact had been absorbed by the dirt and in crushing the forward turnover structure. While no quantitative data regarding volume change could be obtained from film analysis, the photographs during and after the crash indicate that no significant volume change occurred. Figures 32 and 33 show front and side views of the engine mount and mount assembly damage. The left side mounts failed during the test. The right side mounts were damaged in removing the engine. The left side mount assembly was damaged during pretest checkout and was welded for the turnover test.

*Presented in the airplane coordinate system

Figure 30. Side View of Forward Fuselage Damage (Airplane B)



Forward

Figure 31. Side View of Cabin Area and Turnover Structural Damage (Airplane B)

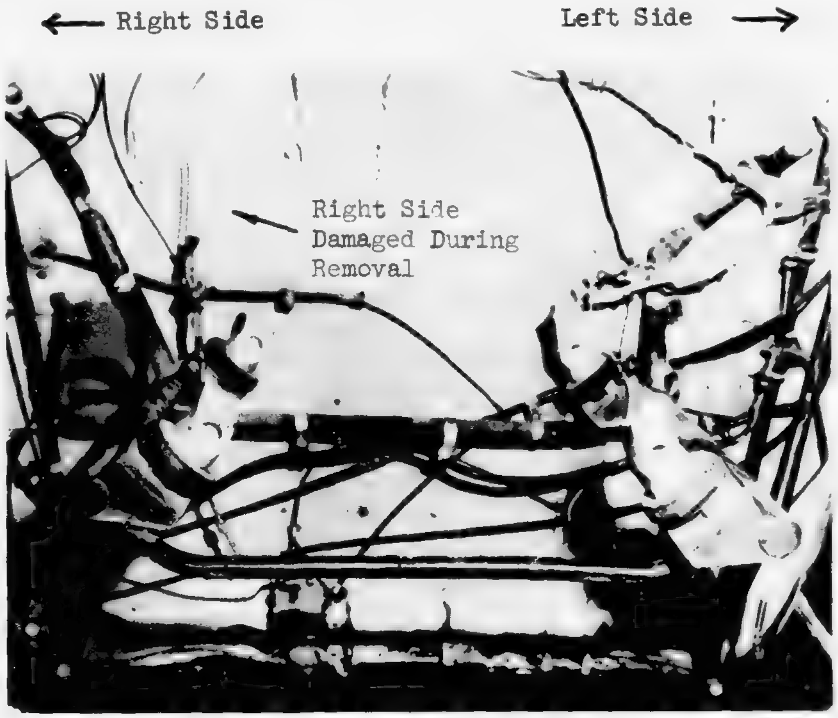


Figure 32. Front View of Engine Mount Failure, Left Side (Airplane B)

Figure 33. Side View of Engine Mount Failure, Left Side (Airplane B)

5.4 MATHEMATICAL MODEL DATA

5.4.1 Airplane A Math Model

The mathematical models for Airplane A are shown in Figures 34 and 35. The crash condition being analyzed involves a forward fuselage (nose) impact into a 45-degree dirt barrier with no initial yaw or roll angles. Due to the symmetry of the crash impact, and the availability of only side-view film coverage, a math model with a reduced number of masses and members can be used to good advantage. The model size reduction is obtained by utilizing a planar model of the fuselage (all masses in the Y = 0 plane). The smaller model size permits an initial checkout, to determine the portions of the model wherein more rigorous modeling requirements are needed, in a more economical manner than that of the larger model. The model shown in Figure 35 consists of 21 masses and 32 members. A description of the mass representations is provided in Table 10. The model coordinates, mass properties, inertia properties, member properties, damping factors, and initial conditions are presented in Appendix C.

The larger model, shown in Figure 34, consists of 35 masses and 69 members. A description of the mass representations is given in Table 11. The model coordinates, mass properties, inertia properties, member properties and damping values are presented in Appendix C.

The internal elements in the math models are represented with linear properties at all locations except as noted below:

Location	21 Mass Model Nonlinear Members	35 Mass Model Nonlinear Members	Type of* Nonlinear Curve(s)
Engine Mount	9-13, 10-13	9-13, 10-13, 11-13, 12-13	5
Fwd. Fuselage	7-10, 6-9	7-10, 6-9, 12-17, 11-16	5
Mid Cabin	4-5, 4-6, 6-7, 7-8, 5-8.	4-5, 4-6, 5-20, 18-20, 19-20, 16-18, 16-19, 6-15, 15-16.	3, 4, 5
Tail Cone	11-17, 12-17	30-32,31-32, 21-32, 22-32	3

*See page 66 for curve types

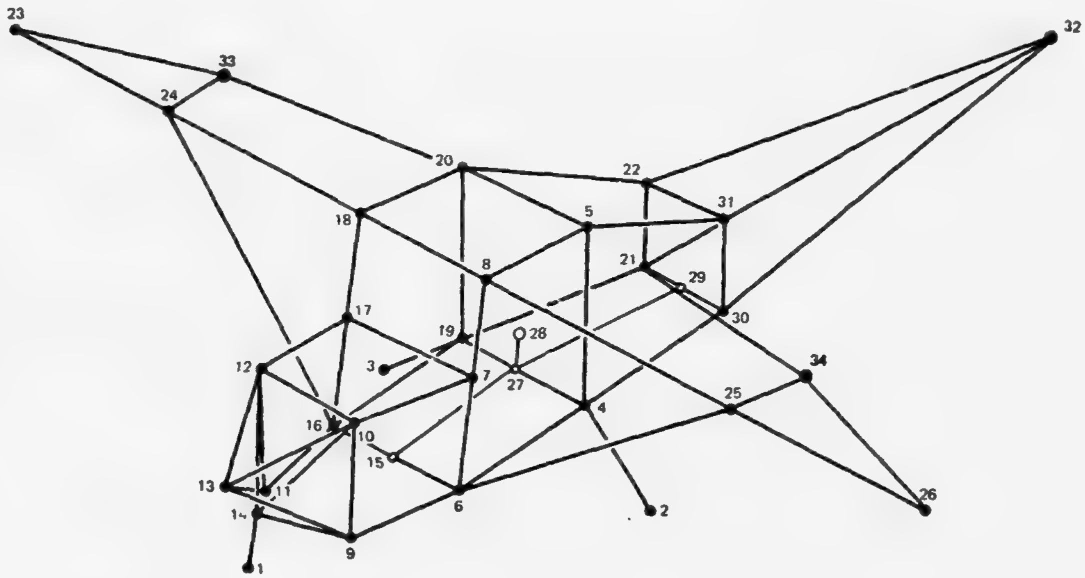


Figure 34. 35 Mass, 69 Member Math Model for Airplane A

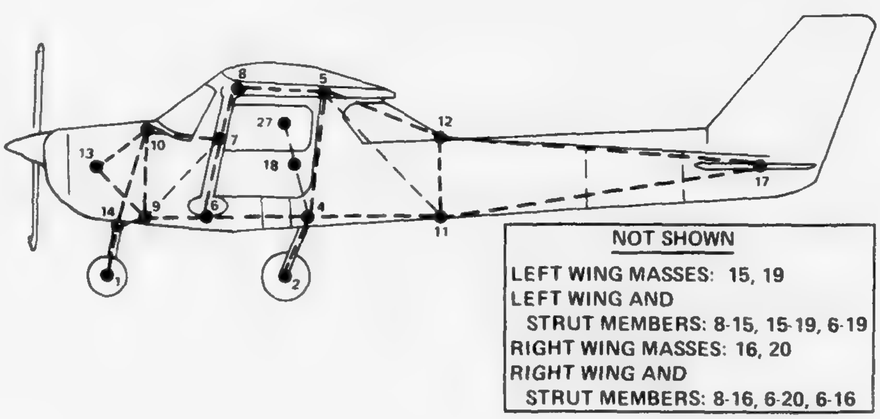


Figure 35. 21 Mass, 32 Member Math Model for Airplane A

TABLE 10. MASS IDENTIFICATION FOR 21 MASS, 32 MEMBER AIRPLANE A MATH MODEL

Mass Point(s)	Representation
1	Nose Gear Unsprung Mass
2,3	Main Landing Gear Unsprung Mass
4,5,6,7,8	Mid Fuselage Cabin Region
9,10	Firewall
11,12	Fuselage Aft Bulkhead
13	Engine
14	Nose Gear Trunnion
15,19	Left Wing
16,20	Right Wing
17	Tail Unit
18,21	Occupant and Seat

TABLE 11. MASS IDENTIFICATION FOR 35 MASS, 69 MEMBER AIRPLANE A MATH MODEL

Mass Point(s)	Representation
1	Nose Gear Unsprung Mass
2,3	Main Landing Gear Unsprung Mass
4,5,6,7,8,16 17,18,19,20	Mid Fuselage Cabin Region
9,10,11,12	Firewall
13	Engine
14	Nose Gear Trunnion
15,27,29	Floor Structure
21,22,30,31	Fuselage Aft Bulkhead
25,26,33	Left Wing
23,24,34	Right Wing
28,35	Occupant and Seat
32	Tail Unit

The nonlinear properties are based on estimates of buckling strengths, available design load data and/or test data. Procedures for obtaining input data are described in the KRASH User's Manual (Reference 13). The standard nonlinear curves incorporated in program KRASH, and described in Section 4.4 of this report, are used.

The procedure for performing the analysis is as follows:

1. Establish both small and large linear models
2. Using the 'model parameter' printout data described in Section 4.4:
   a) determine if the model accurately reproduces airplane C.G. and vehicle mass properties,
   b) determine if the stiffness and damping factor values will potentially cause instability problems, and
   c) refine model mass and stiffness properties, if required.
3. Using the smaller model, initiate analysis for a limited time duration (approximately 20 to 40 milliseconds) and determine energy flow distribution. Use initial estimate of external force-deflection curve with initial impact velocities, rates and angles.
4. Refine the smaller model nonlinear representations and perform longer duration checkouts.
5. Perform checkout with larger model, using nonlinear representations based on the results of the smaller model analysis, for a short duration time period.

Preliminary analytical runs were made to verify that the nose gear fails and in so doing does not absorb significant energy nor change the attitude at impact of the spinner with the barrier. The initial spinner impact velocity was based on film analysis.

A description of the use of the 'model parameter data', the energy distribution printout, the external force-deflection curves, and how failure loads are estimated is presented in Section 3 of Reference 13.

Table 12 shows a comparison of the Airplane A and math model C.G. and mass properties. The math model C.G. is within 0.6 inches of the estimated fuselage station and within 2 inches of the waterline, respectively, compared to the

TABLE 12. COMPARISON OF AIRPLANE A AND MATH MODEL C.G. AND MASS PROPERTIES

	Airplane A	Math Model[a]	Difference Inches	Difference Percent[b]
C.G.				
FS, inches	36.9	36.32	.58	
BL, inches	.28	0.0	.28	
WL, inches	1.85	3.77	1.92	
Weight, lb.	1600	1600		0
Moment of inertia, lb.-in.-sec.^{2}				
I_x (roll)	9000	9243		2.7
I_y (pitch)	9657	10186		5.5
I_z (yaw)	16192	16366		1.1

(a) average of small and large model

(b) $\frac{\text{model value - airplane value}}{\text{airplane value}} \times 100$

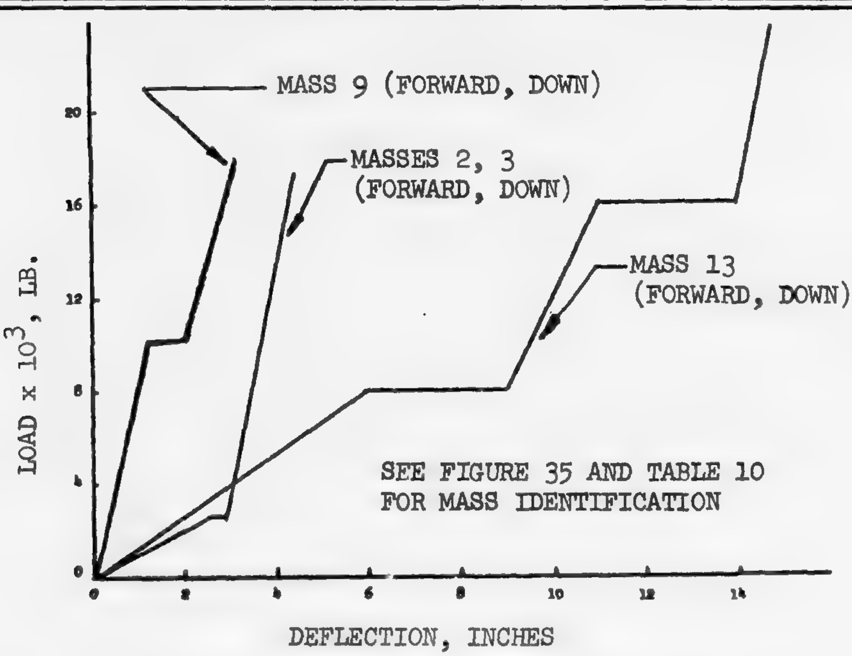


Figure 36. External Spring Load - Deflection Characteristics Used in the Math Model For Airplane A

airplane C.G. The math model inertia properties are within at least 5.5 percent of the estimated airplane values. Actual airplane inertia properties for the test configuration are not available. The external load-deflection characteristics used for Airplane A are shown in Figure 36. The results of the analysis and comparison with test data are given in Section 5.5.1.

5.4.2 Airplane B Math Model

The mathematical models for Airplane B are shown in Figures 37 and 38. The crash condition being analyzed involves an airplane moving at a forward velocity while pitching and rotating nose down. The forward section of the airplane digs into the dirt and the airplane rotates tail over onto its turn-over structure. The time duration of the complete crash is approximately 1.7 seconds which is an order of magnitude longer than the significant portion of a typical crash. For most of that time no significant damage occurs. Consequently, this type of accident is idealized as two separate impacts. The damage sustained during the initial impact is included in the model when treating the second impact condition. The technique of using two models (small and large) for each impact is adopted for this crash analysis for the same reasons as that of the analysis of Airplane A. The models developed for the initial forward fuselage impact are similar to the models needed to analyze the second impact (overturn) except for some minor changes such as location of external contact springs and the representation of structure that is damaged during the initial impact. The model shown in Figure 38 consists of 25 masses and 38 members. A description of the mass representations is provided in Table 13. The mass coordinates, mass properties, inertia properties, member properties, damping factors, and initial conditions are presented in Appendix C. Differences in the modeling of the two separate impacts during the turnover are noted in Figure 38 and Table 13.

The larger model, shown in Figure 37, consists of 44 masses and 81 members. A description of the mass representations is presented in Table 14. The mass coordinates, mass properties, inertia properties, member properties,

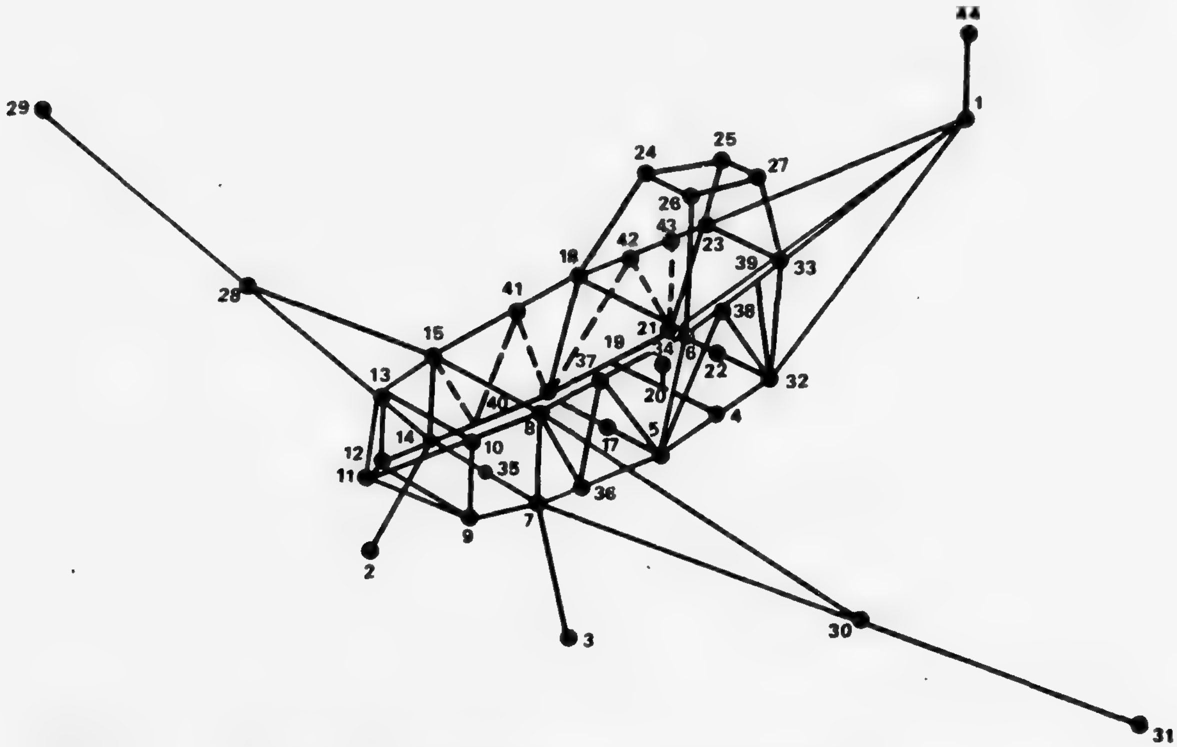


Figure 37. 44 Mass, 81 Member Math Model for Airplane B

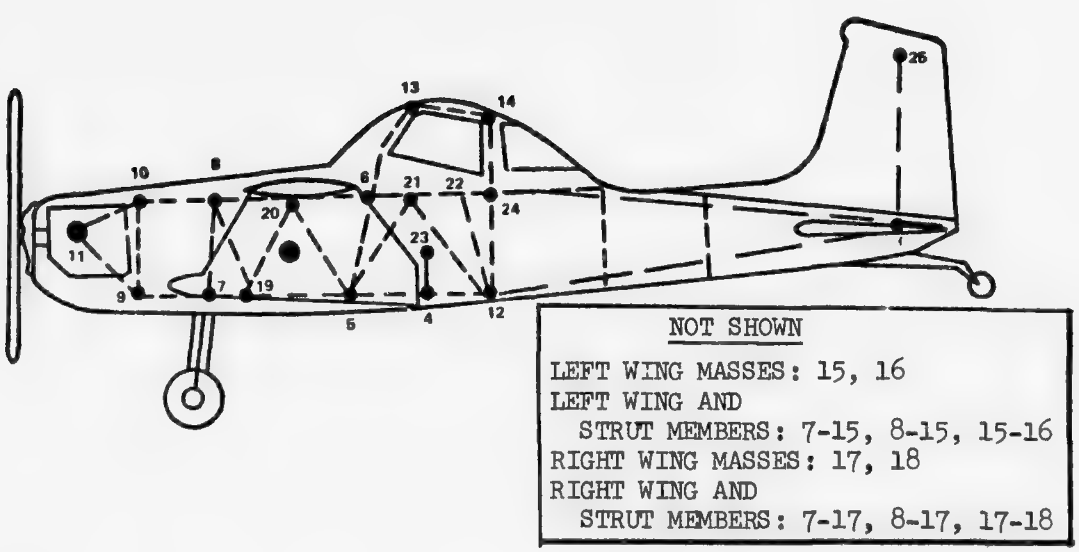


Figure 38. 25 Mass, 38 Member Math Model for Airplane B

TABLE 13. MASS IDENTIFICATION FOR 25 MASS, 38 MEMBER AIRPLANE B MATH MODEL

Mass Point(s)	Representation
1	Tail Unit (including tail wheel)
2,3	Main Landing Gear Unsprung Mass
4	Floor Structure Mid Fuselage
5,6,7,8	Fuselage, Hopper Region
9,10	Firewall
11	Engine
12,24	Fuselage Aft Bulkhead
13,14	Forward and Aft Turnover Structure
15,16	Left Wing
17,18	Right Wing
19,20,21,22	Fuselage Welded Tube Structure
23	Occupant and Seat
25 (a)	Vertical Tail Unit

(a) This mass is used for the turnover impact only. It is included with mass 1 for the initial impact.

TABLE 14. MASS IDENTIFICATION FOR 44 MASS, 81 MEMBER AIRPLANE B MATH MODEL

Mass Point(s)	Representation
1	Tail Unit (including tail wheel)
2,3	Main Landing Gear Unsprung Mass
14,17,19, 20,22,35	Floor Structure, Forward and Mid Fuselage
5,6,7,8,14 15,16,18	Fuselage, Hopper Region
9,10,12,13	Firewall
11	Engine
21,23,32,33	Fuselage Aft Bulkhead
24,26,25,27	Forward and Aft Turnover Structure
28,29	Right Wing
30,31	Left Wing
34	Occupant and Seat
36 thru 43	Fuselage Welded Tube Structure
44 (a)	Vertical Tail

(a) This mass is used for the turnover impact only. It is included with mass 1 for the initial impact.

damping factors, and initial conditions are presented in Appendix C. The data shown in Figure 37 and Table 14 are used for both impacts during the turnover crash, except where noted.

As discussed in the presentation of the test data (Section 5.3.2.4), there is relatively little structural deformation in the initial impact except for the engine cowling, and the applicable acceleration response data is limited. Consequently, of prime concern in the modeling of the turnover test is the requirement to reproduce the airplane large rigid body motions and the multiple impacts that occur. The forward fuselage impact is modeled using external springs. The ground is represented, in the locality of the impact point, as a mound of dirt with a face at 90 degrees to the ground plane having a coefficient of friction of 1.0, so that the line of action of the resultant forces acts on the airplane to slow down its motion as it approaches a vertical position. Other than the external springs that represent the crushing of the structure and ground plowing, the only nonlinear elements are the engine mounts (Figure 39). The wing tips and tail impacts and subsequent deformations are considered to have a minor effect on the resultant airplane motions and, accordingly, are represented as linear elements. Table 15 shows a comparison of the Airplane B and math model C.G. and mass properties. The math model C.G. is within 0.33 inches of the estimated airplane value. The inertia properties are within 12.8 percent of the estimated airplane properties. Actual airplane inertia properties for the test configuration are not available. The nonlinear curves used for the turnover crash test are shown in Figure 39. The procedure for performing the turnover crash analysis is the same as that described in the previous section for the stall-spin crash analysis.

Linear internal elements are used in the math models at all locations except as noted on the following page.

Location	25 Mass Model Nonlinear Members	44 Mass Model Nonlinear Members	Type of* Nonlinear Curve(s)
Engine Mount	9-11,10-11	9-11, 10-11, 11-12, 11-13	3,4
Turnover Structure	6-13, 14-22 13-14	18-24, 6-26, 23-25, 27-33, 24-25, 26-27	3

*See page 66 for curve types

The nonlinear properties are based on the estimates of buckling strengths, available design load data and test data. Procedures for obtaining input data are described in the KRASH User's Manual (Reference 3). The standard nonlinear curves contained in KRASH (Section 4.3) are used. The results of the analysis and comparisons with test data are presented in Section 5.5.2.

TABLE 15. COMPARISON OF AIRPLANE B AND MATH MODEL C.G. AND MASS PROPERTIES

	Airplane B	Math Model[a]	Difference Inches	Difference Percent[b]
C.G.				
FS, inches	41.	41.33	0.33	-
BL, inches	.12	-.122	.142	-
WL, inches	2.0	2.248	.248	-
Weight, lb.	2475	2475	-	0
Moment of inertia, lb.-in.-sec.^{2}				
I_x (roll)	19700	17185	-	-12.8
I_y (pitch)	23250	25804	-	11.0
I_z (yaw)	38450	38680	-	0.6

(a) average of small and large model

(b) $\frac{\text{model value - airplane value}}{\text{airplane value}} \times 100$

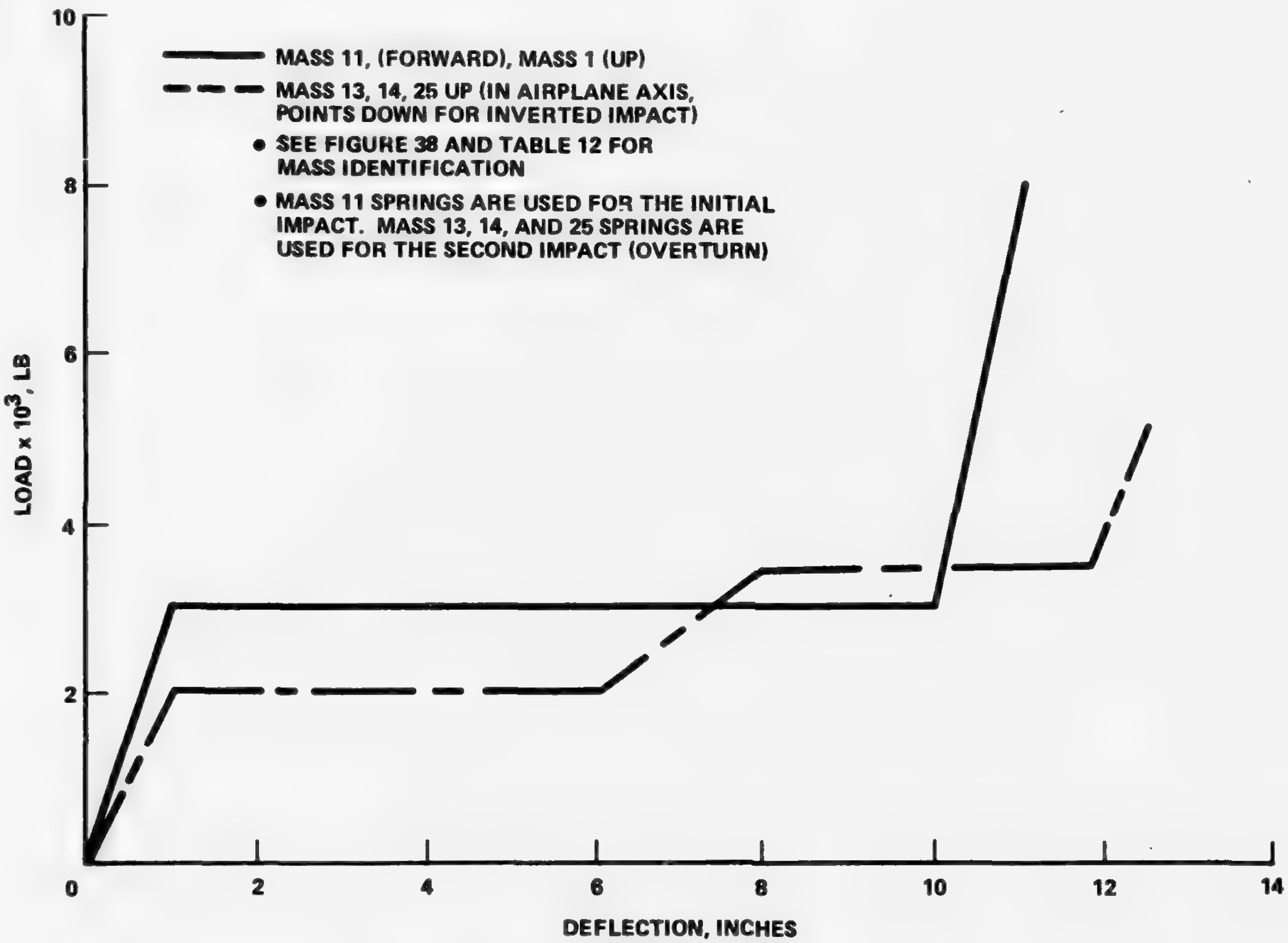


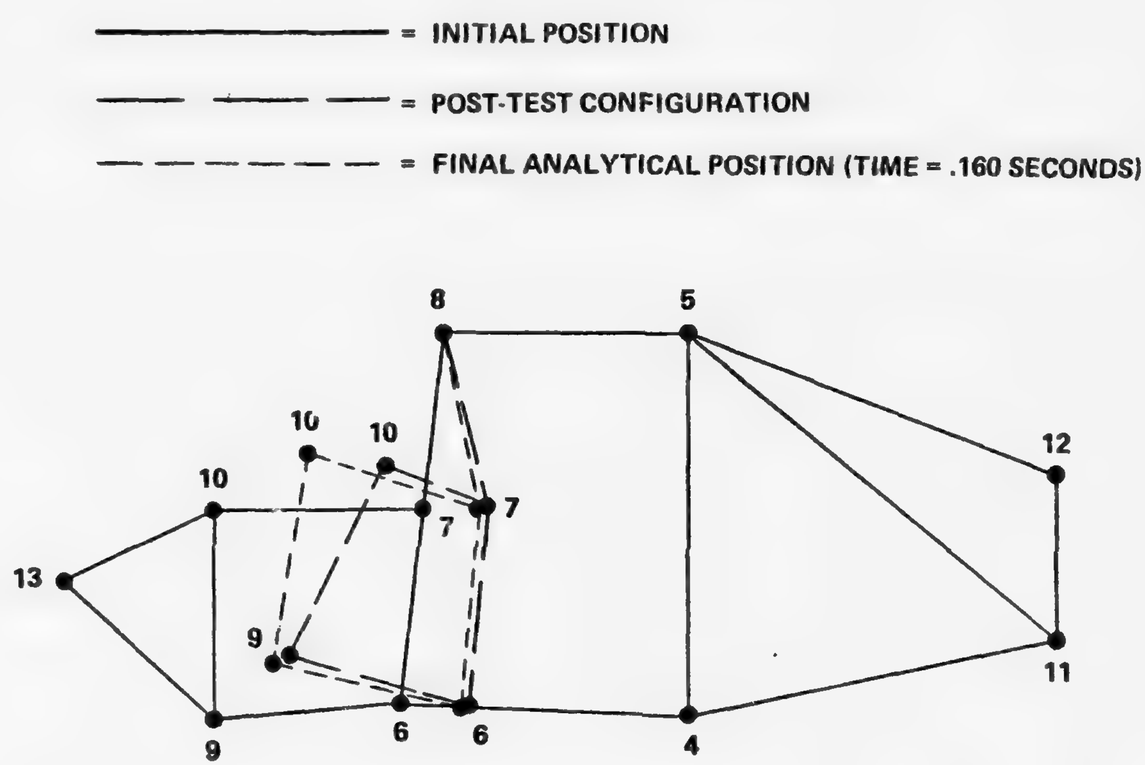
Figure 39. External Spring Load - Deflection Characteristics Used in the Math Model for Airplane B

5.5 COMPARISON OF ANALYSIS AND TEST RESULTS

5.5.1 Airplane A Comparison

The crash condition analyzed consists of a longitudinal approach velocity of 45 feet per second into a 45 degree earthen slope. In the actual test, the nose gear fails aft immediately without appreciably altering the kinetic energy of the airplane. Preliminary analysis is performed to show that the nose gear fails in this manner and thereafter the analysis commences with the spinner impacting the slope. From inspection of Figures 21 through 26, it can be seen that the most significant vehicle damage is the crushing of the structure forward of and below the engine, and the subsequent rearward deflection and upward rotation of the engine. The upper engine mounts buckle and the forward cabin area deflects rearward substantially. Also highly visible, but not too significant from the occupant safety viewpoint, is the failure of the aft fuselage.

Figure 40 shows a comparison between test and analytical results of the post test deflected position of the engine and cabin structure. The test results are based on measurements made from photographs. The analyses results are based on the math model shown in Figure 35. Figure 40 demonstrates good overall agreement between test and analysis for the engine deflection and rotation and the cabin deformation. The analytically obtained deflected position corresponds to the end of the analysis at 0.16 seconds after spinner impact. Figure 41 presents the sequence of the vehicle deformations. The rearward deflection of the center of the forward door post (mass 7) and the shortening of the cabin floor (beam 4-6) occur quite early in the crash. The buckling of the engine mounts and the full deflection and rotation of the engine and upper cowl structure take a longer time to develop. The phasing of the significant internal beam element deflections is given in Figures 42 and 43. All the beam elements shown in Figures 42 and 43 utilize nonlinear KR curves that incorporate restiffening after the structural elements have been exposed to substanial deflection in the post failure region at low loads. The restiffening



NOTE: (1) DIAGONAL ELEMENT 7-9 OMITTED FOR CLARITY
(2) MASS 13 NOT SHOWN IN DEFLECTED POSITIONS FOR CLARITY

Figure 40. Comparison of Test and Analytical Airplane Deformations (Airplane A).

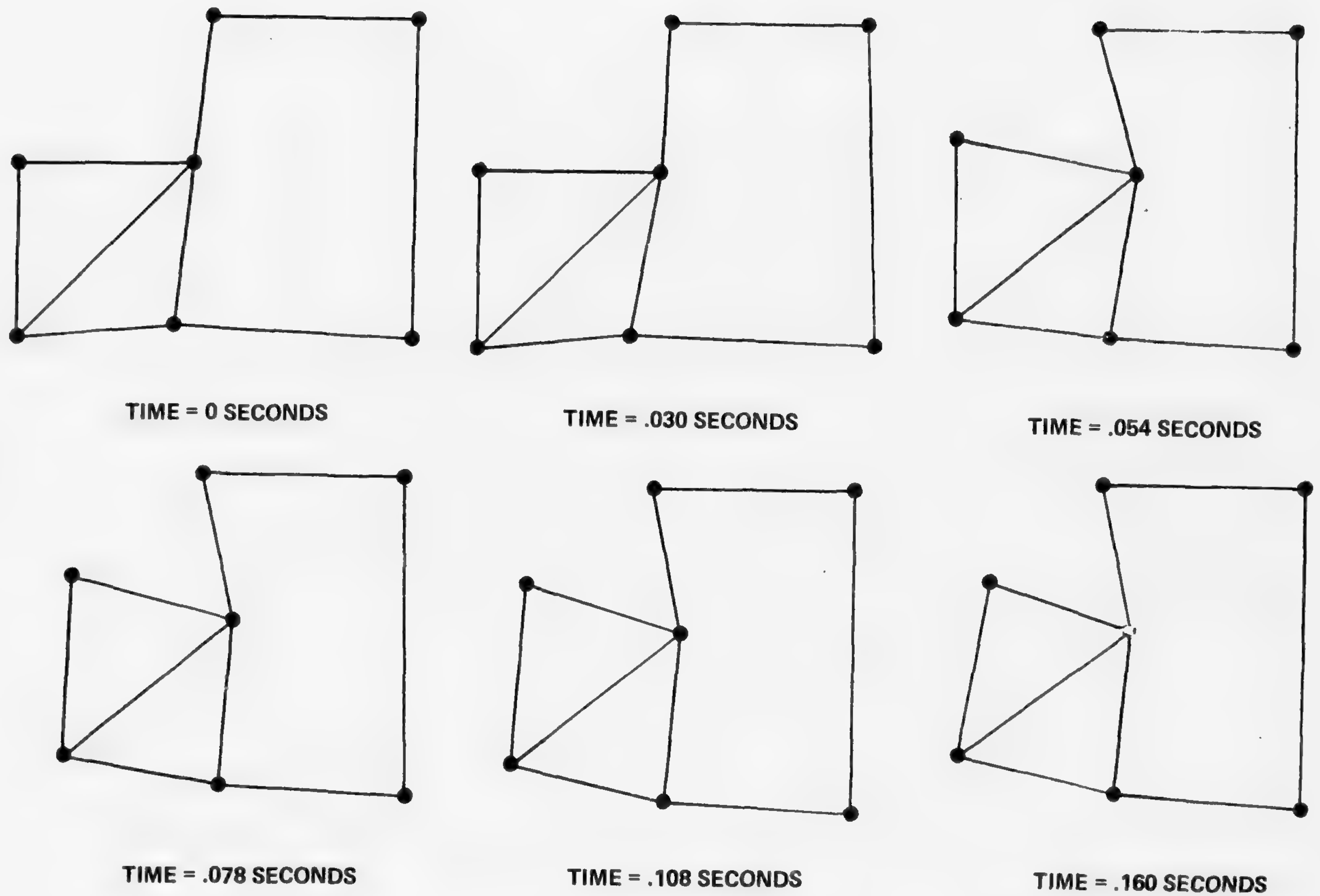


Figure 41. Sequence of Cabin Deformation Obtained from Analysis (Airplane A).

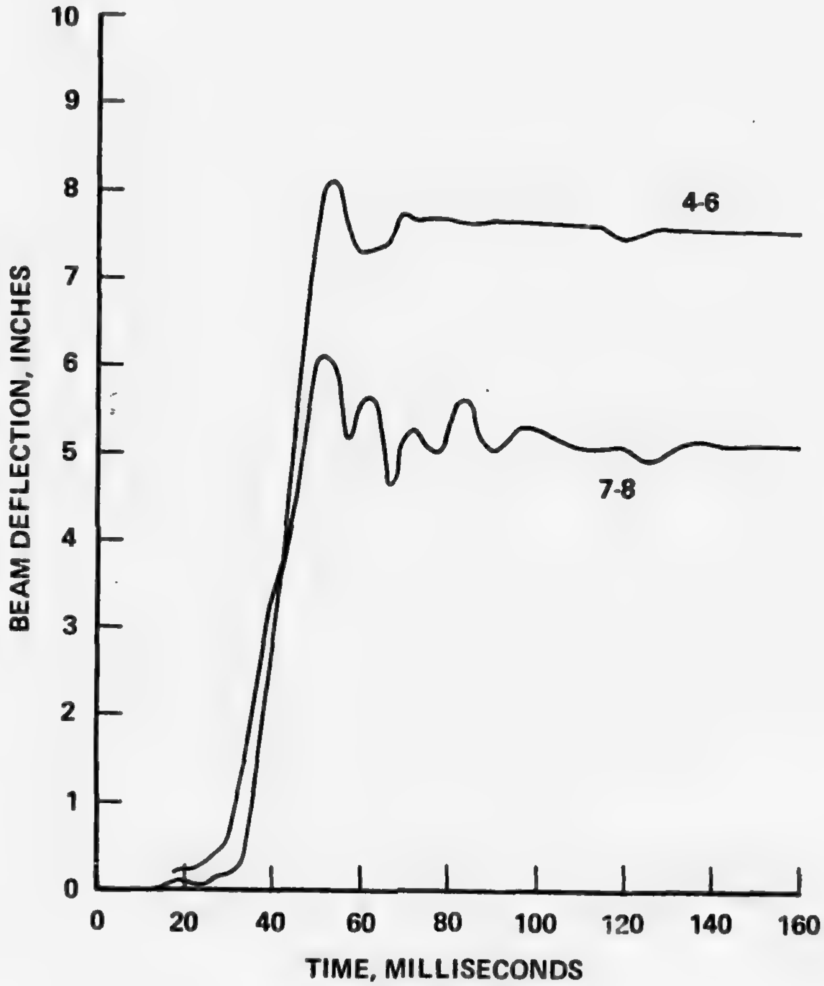


Figure 42. Internal Beam Deflection Time Histories Obtained from Analysis, Cabin Area (Airplane A)

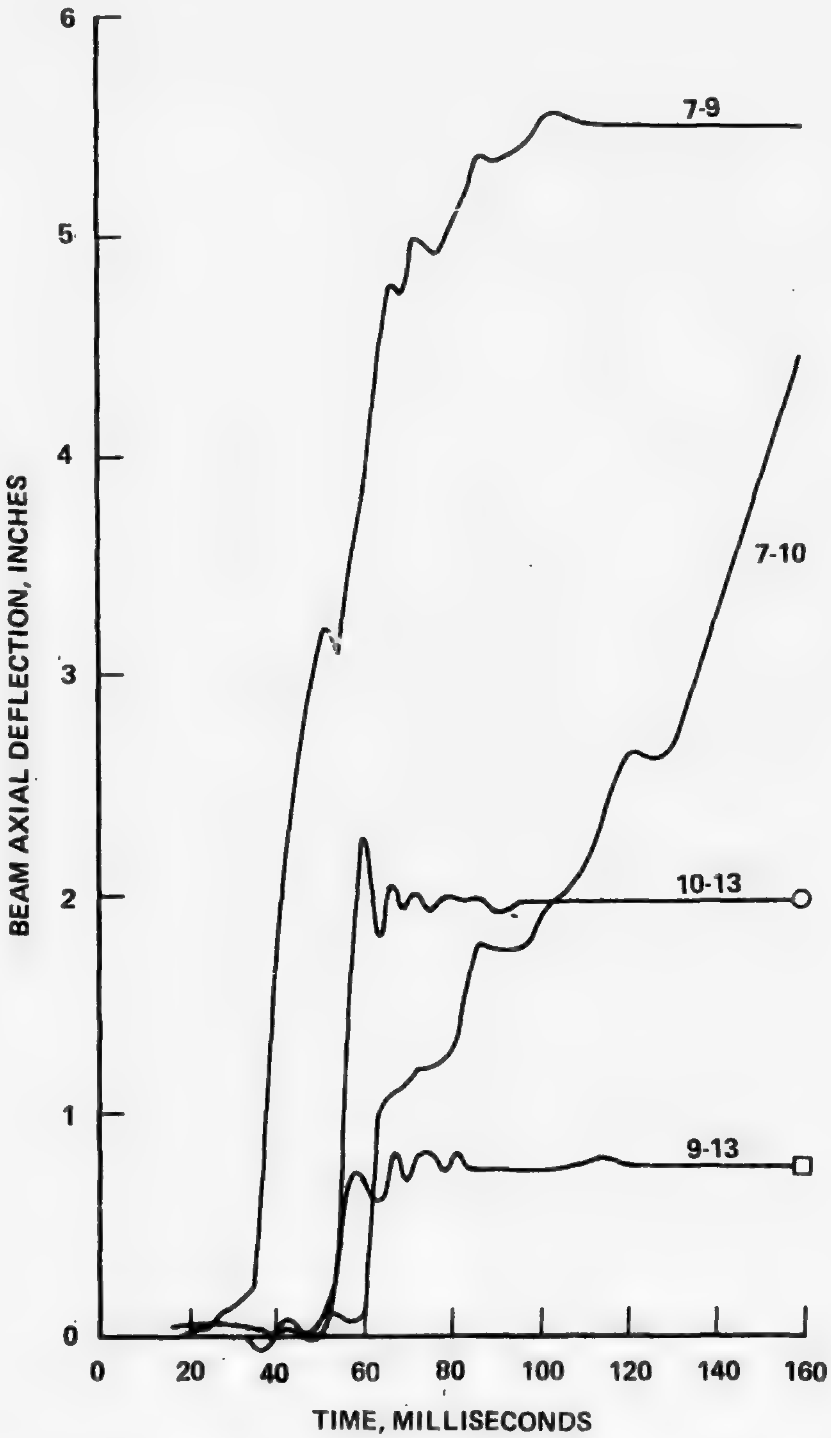


Figure 43. Internal Beam Deflection Time Histories, Forward Fuselage Structure and Engine Mounts Obtained from Analysis (Airplane A)

represents the crushing of structure in a confined region. Test data from Reference 4 shows this phenomenon and the observations from those tests combined with the geometry associated with the airplane structure are used to determine when restiffening can occur. All the internal structural elements shown in Figures 42 and 43 have reached the restiffening deflections except the upper cowl structure (beam 7-10). However, from the trend of the history of the axial deflection of element 7-10 (Figure 43), it is evident that its restiffening deflection of approximately 9 inches would be reached by 0.25 second after spinner impact. This additional deflection would further improve the correlation between the test and the analysis final deflected position shown in Figure 40.

Figure 44 shows a comparison of analytical and test results for cabin deformation, consisting of the rearward deflection of the forward door post. The correlation at WL 19.1, which is near the top of the door frame, is quite good. At WL 2.4, near the center of the door, the correlation is good in the initial loading region, but the test results indicate a peak deflection of around 10 inches at 140 milliseconds, with a final deflection of 9 inches, while the analysis predicts about 7 inches constant beyond 100 milliseconds. This is consistent with the results shown in Figure 40, which indicate that the analytical aft deflection of mass 7 is less than the test results.

Figure 45 shows the time histories of the external spring deflections. Springs 13-1 and 13-3 (Figure 36) represent the airplane structure forward of and below the engine. Also incorporated in the load-deflection curves for these springs is an approximation of the compliance or softness of the ground. The springs at mass 9 are much shorter and absorb far less energy than those at mass 13. From Figure 45 it can be seen that the external springs at mass 13 develop their peak loads within 35 milliseconds and then unload gradually during the remainder of the run having a secondary peak at 90 milliseconds. The springs at mass 9 contact later but also reach an initial peak at 35 milliseconds, and then reload later to a second peak at 90 milliseconds.

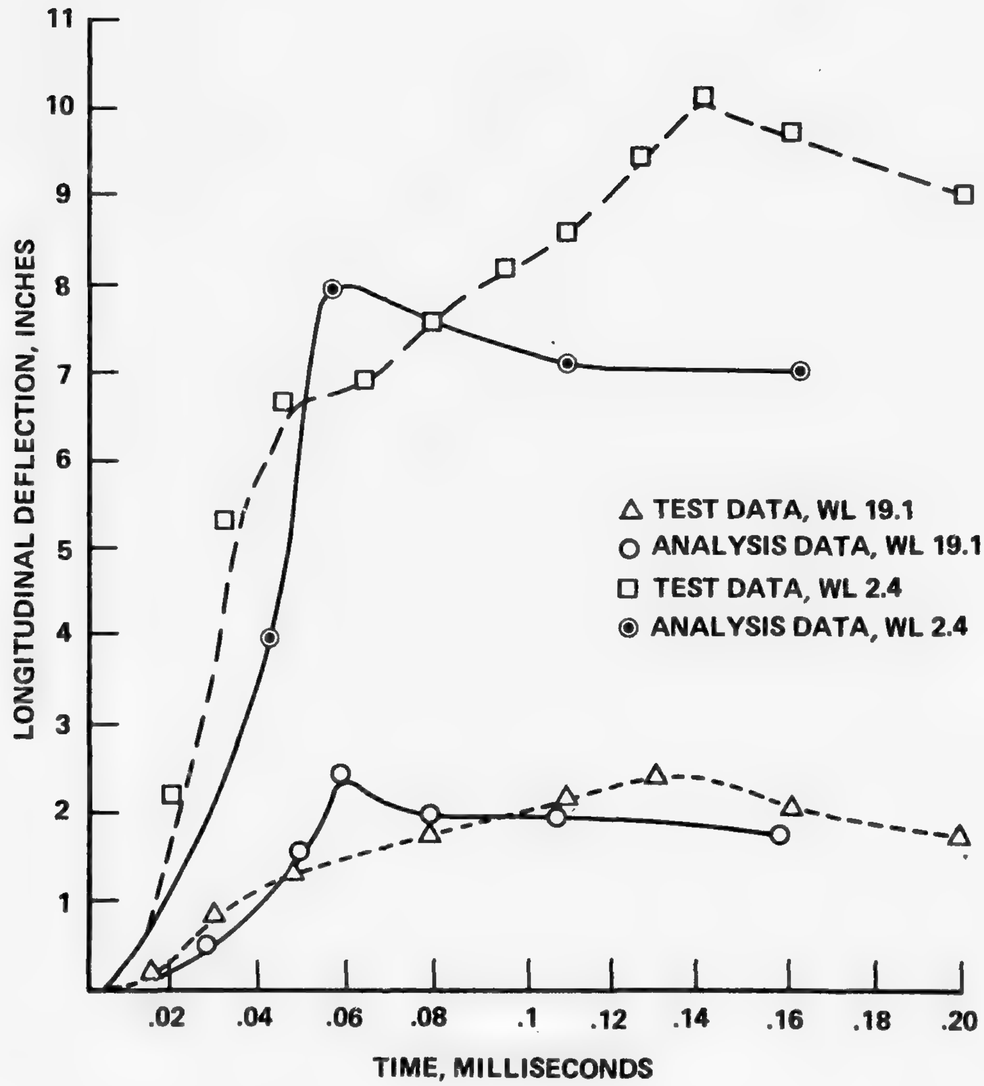


Figure 44. Comparison of Analysis and Test Data for Cabin Deformation (Airplane A)

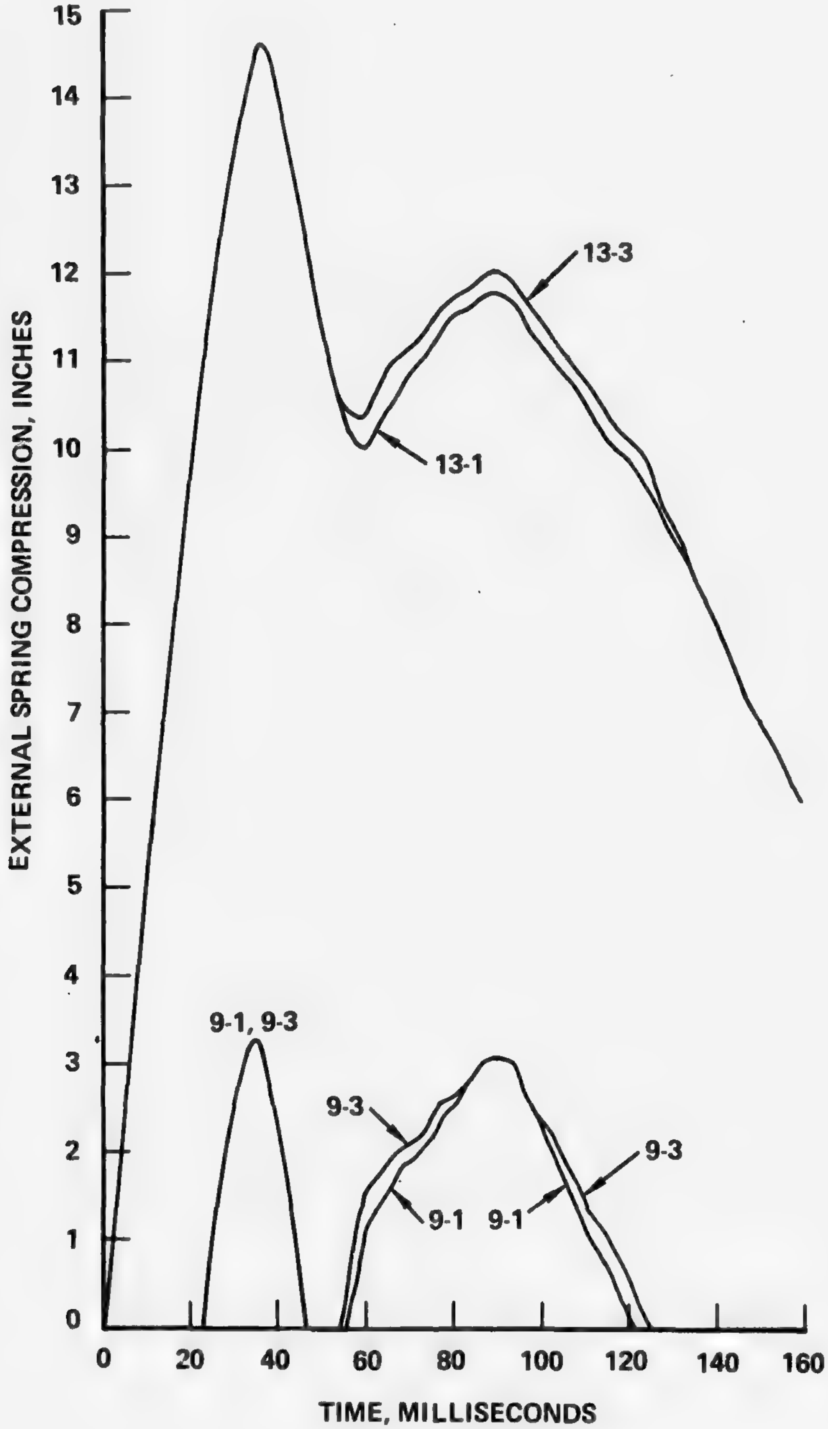


Figure 45. External Spring Deflection Time Histories Obtained from Analysis (Airplane A)

Inspection of Figures 42 and 43 indicates that the internal element structural deformations all begin after 30 milliseconds when the external springs have nearly developed their peak loads. The line of action of the external forces acting on the external springs at mass 13 is such that elements 4-6 and 7-8 quickly deflect aft, while 6-9 and 7-10 retain their integrity initially. Simultaneously, the external spring loads at mass 9 cause the diagonal element 7-9, which represents the shear capability of the fuselage side structure, to deform. Only after this element has deflected almost to its maximum value does the upper element 7-10 begin to shorten. Once 7-9, 7-8, and 4-6 have all deformed sufficiently to reach their restiffening regions, both member 7-10 and the upper engine mount 10-13 begin to deform significantly, with 10-13 buckling rather quickly between 50 and 60 milliseconds.

The tail cone fails at 75 milliseconds in the analytical model, with the lower element 11-17 failing in compression (buckling). At the time of failure, the tail section has bent downward just over 2 inches. After the failure of 11-17, the tail cone structure is reduced to only element 12-17. This beam fails in vertical bending at 108 milliseconds. The tail cone failure sequence and timing are consistent with the crash test film data. In the analytical model, no attempt is made to simulate the very large deflections and rotations of the tail cone observed in the crash test. While the tail cone "flapping" is a predominant motion in the motion pictures of the crash test, this motion is not of great importance to the question of occupant survivability. Therefore, in the analytical model, the tail cone is treated as completely failed (ruptured) once the buckling failure mode is well established.

Figure 46 shows a comparison between the test and analytical time histories of total airplane kinetic energy. The test results are based on velocities deduced from analysis of the film data. Minor velocity fluctuations in the test data have been smoothed out prior to calculating the kinetic energy. The agreement between analysis and test results shown in Figure 46 is quite good, and indicates that the energy absorption in the analytical model is very reasonable. Two percent structural damping was used for all the members.

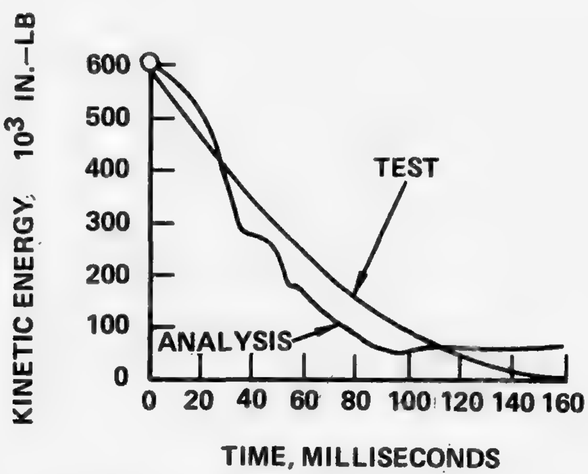


Figure 46. Comparison of Test and Analytical Kinetic Energy Time Histories (Airplane A)

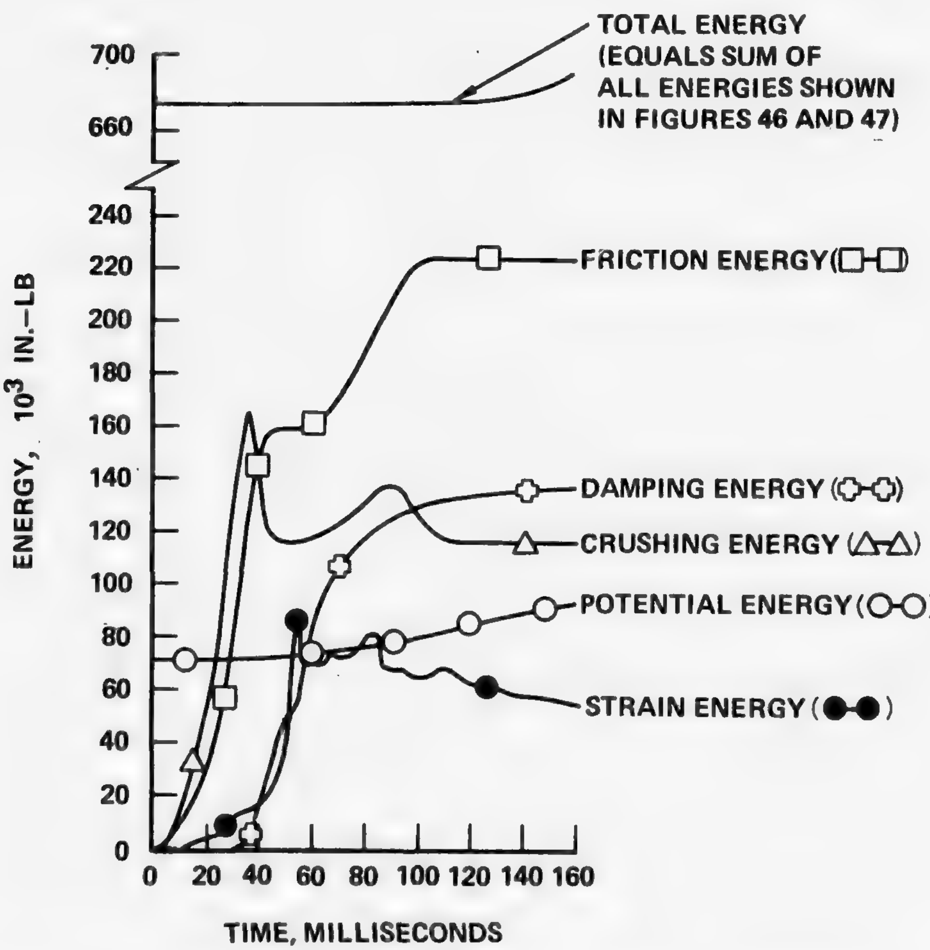


Figure 47. Time Variation of Analytical Energy Components (Airplane A)

Figure 47 illustrates the time variation of the various energy terms which account for the reduction of the kinetic energy in the analytical model. The terms shown are the friction energy (FE) and crushing energy (CE) associated with the external springs, the strain energy (SE) and damping energy (DE) of the internal beams, and the potential energy (PE) of the vehicle. Figure 47 shows the nature of the energy absorption in the system. Prior to about 40 milliseconds, the entire energy absorption is due to the friction and crushing energies of the external springs. From 40 to 60 milliseconds the strain energy of the internal beams increases from virtually zero to its peak value. The damping energy also increases rapidly during this time span, but continues to increase significantly during the remainder of the analysis. There is a slight increase in the potential energy during the run that results from the vehicle riding up the earthen slope. The energy absorption results of Figure 47 are consistent with the deflection time histories observed earlier; initially the external springs are compressed, driving the internal beams which respond somewhat later.

In Figure 47 it can be seen that both the friction energy and the damping energy are monotonically increasing quantities, while the strain and crushing energies peak and fall. This behavior is attributed to the fact that the friction and damping energies are both dissipative; the energy is converted to heat and cannot be reintroduced into the system. The behavior of the strain and crushing energies, on the other hand, results from energy storage in structural elements which are partially elastic, and therefore part of the peak energy absorbed is reintroduced into the system when the members unload elastically. The flat portion of the friction and crushing energy curves between 45 and 60 milliseconds and beyond 115 milliseconds result from the fact that in these regions all external springs have unloaded to a zero load level; between 60 and 115 milliseconds the springs on mass 9 have reloaded.

At the end of 160 milliseconds of analysis the total energy has increased by only 2.5 percent from its original time = 0 value which indicates that the math model is behaving in a stable manner.

Also available from the output of program KRASH is the spatial distribution of the strain energy at each time print. Table 16 is a

TABLE 16. STRAIN ENERGY SPATIAL DISTRIBUTION, AIRPLANE A ANALYSIS

	Percentages of Total Strain Energy								
	Engine Mounts		Firewall & Fuselage Structure Aft of the Firewall				Mid Cabin		
Time \ Beam	9-13	10-13	6-9	7-9	7-10	9-10	4-6	6-7	7-8
.012	22.8	16.5	6.3	0	4.5	2.28	19.3	13.4	11.3
.018	7.6	9.6	1.8	0.2	6.2	1.66	16.1	28.0	20.1
.024	2.3	12.0	0.4	0.8	8.7	1.11	6.3	37.1	24.2
.030	0.2	2.8	3.8	6.4	2.5	0.24	19.6	31.4	25.7
.036	9.0	5.2	5.3	8.2	0.9	1.32	25.6	3.2	30.3
.042	4.0	1.6	23.1	6.1	7.6	1.86	17.6	1.9	16.0
.048	2.1	2.0	20.3	3.7	9.5	0.78	9.4	3.0	23.7
.054	3.2	2.6	12.0	2.5	6.8	0.52	20.0	14.1	19.8
.060	8.6	19.8	11.2	1.6	10.5	4.72	7.4	1.6	9.7
.066	4.0	14.9	15.2	1.5	16.3	3.20	6.3	1.6	9.6
.072	11.7	7.6	18.3	1.7	16.7	1.99	6.9	4.4	8.2
.078	8.7	6.2	13.2	2.0	16.3	4.14	7.2	4.9	14.1
.084	7.4	8.1	15.8	1.5	15.1	2.23	4.2	6.5	11.1
.090	6.8	11.0	18.5	1.9	18.6	3.30	5.2	4.1	10.1

summary of the time variation of the percentages of the total strain energy accounted for by the internal beams that absorb most of the energy. Figure 48 is a plot of the data from Table 16, where the percentages from the individual beam elements in each airplane region have been added. While the oscillations in Figure 48 are complex, the essential trends are that the strain energy is initially concentrated primarily in the cabin region, and during the crash the strain energy concentration shifts to the fuselage structure aft of the firewall (members 6-9, 7-9, 7-10). The percentage of the total strain energy in the cabin region reduces from a peak of 75 percent at 30 milliseconds to 20 percent at 90 milliseconds. During the same time span the strain energy associated with the fuselage aft of the firewall has risen from approximately 12 percent to 40 percent of the total strain energy. During this time period the strain energy associated with the engine mounts has oscillated about a fairly constant value of 25 percent of the total strain energy. The energy attributed to cabin deformation is greater than the contribution from the fuselage or engine structure deformation up until 60 milliseconds after impact. This result is consistent with the analytical results shown in Figures 41 through 44.

While it might be expected that the strain energy concentration will start near the impact region and flow rearward during the crash, the actual concentration pattern depends on the relative stiffnesses of the various regions of the airplane. For this particular airplane the film analysis indicates that structural buckling occurs in several regions at or shortly after impact. For example, from Figure 20, which provides a partial sequence of the crash event, at approximately 20 to 60 milliseconds after impact there is noticeable damage in the cabin and the structure forward and aft of the cabin. At 100 milliseconds after impact the deformation has progressed significantly. Thereafter, the damage to the fuselage structure aft of the firewall and forward of the cabin continues to develop to a much greater extent than in the cabin area itself. The film analysis shows the maximum cabin deformation has been passed while the fuselage structure aft of the firewall continues to deform. While the computer analysis shows that the maximum cabin deformation transpires earlier than

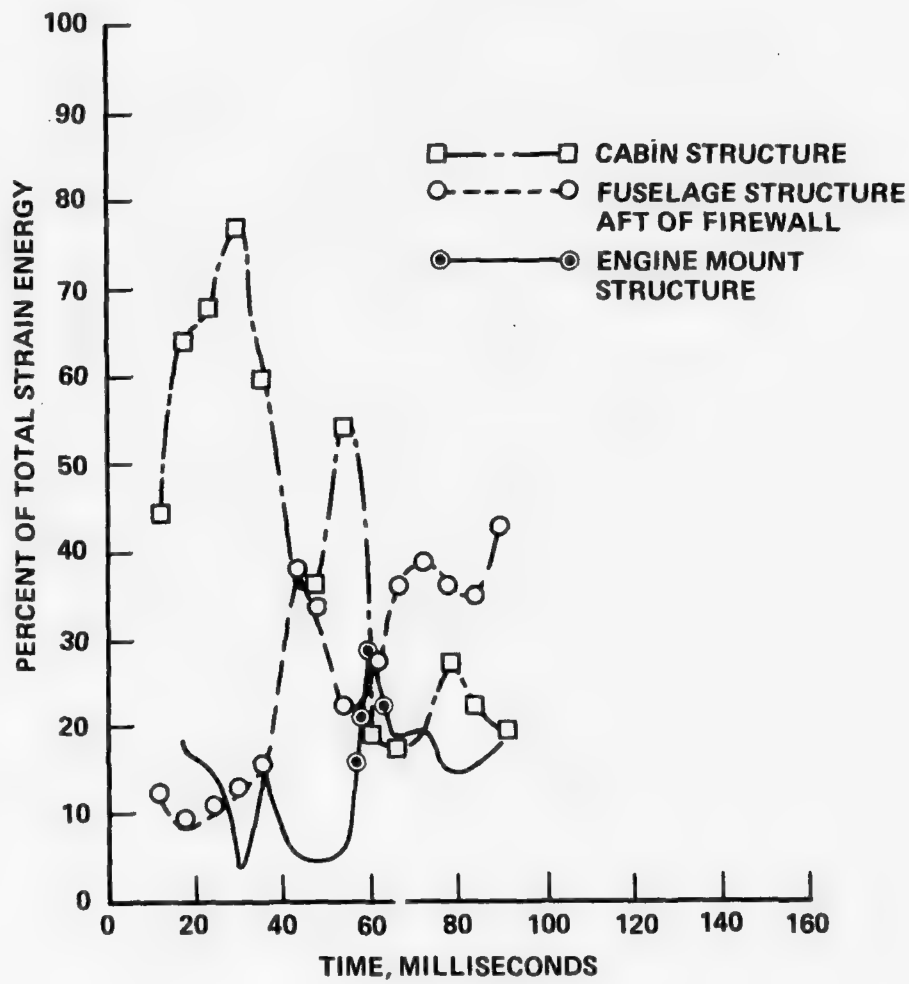


Figure 48. Time Variation of Strain Energy by Region Obtained from Analysis (Airplane A)

the film analysis indicates, it appears that the math model shows a reasonably good relationship between the sequence of events as depicted by the concentration of energies.

Figures 49 and 50 show the cabin floor longitudinal and vertical acceleration histories, both analytical and test results. The analytical results are for mass 4. In both cases, the test results reach their peak in 12 milliseconds, whereas the analytical peaks occur from 50 to 75 milliseconds. Figures 49 and 50 indicate a large discrepancy between test and analytical accelerations. However, examination of the test sequence and related data indicates that the measured test results are most likely not valid for the following reasons.

1. As discussed in Section 5.3.1.4 all the accelerometer signals appear to be activated simultaneously. Considering that the accelerometers measured vertical and longitudinal responses for the structure and occupant (pelvis and head) at different locations and directions and with different individual frequency responses, it is highly improbable that the peak responses for all would occur at the same time and with the same pulse shape.

2. The measured test peak acceleration occurs at approximately 12 milliseconds after impact while the sequence of the crash test (Figure 20) indicates that a maximum response might occur at or after 40 to 60 milliseconds. The analysis shows peak responses between 50 and 75 milliseconds.

3. If, in fact, the measured test responses are valid, it would represent a very localized response appropriate to a very small mass. If the test acceleration pulse acted on the entire vehicle, the initial forward velocity of 45 ft/sec would be stopped in 20 milliseconds. From the film data it appears that the forward velocity is stopped in approximately 160 milliseconds, at an overall average rate of deceleration of about 8.7 g's.

4. Data presented in Reference (12), showing the magnitude of impact velocities and acceleration pulses for a 95th percentile accident condition for light fixed-wing aircraft, supports the analytical results. The 95th percentile longitudinal velocity is given as 50 ft/sec and the associated peak acceleration pulse is 30 g's and 24 g's in the cockpit and passenger compartment, respectively. Furthermore, the duration of the pulse is given as over 100 milliseconds. While the results obtained in this analysis consist of five or six individual separate cycles, the envelope of these cycles has a duration of about 100 milliseconds.

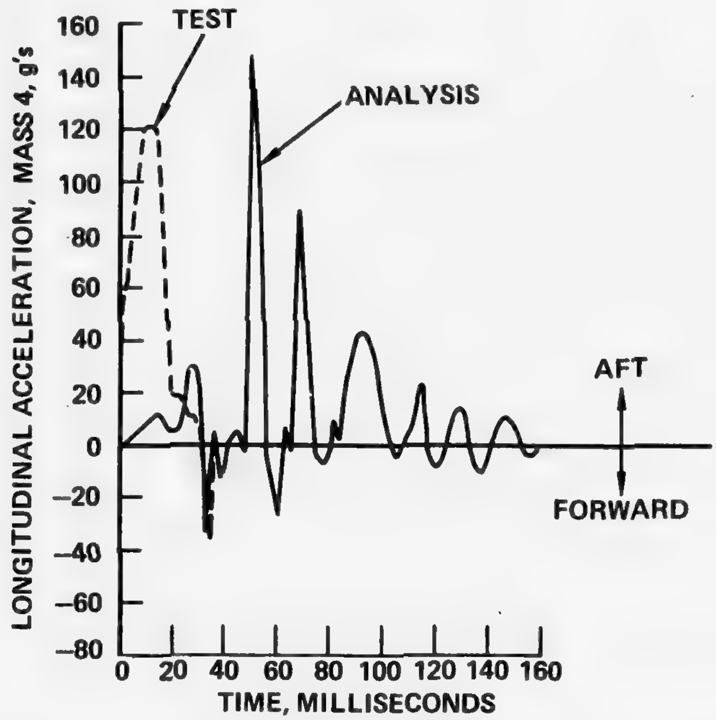


Figure 49. Cabin Floor Longitudinal Acceleration (Airplane A)

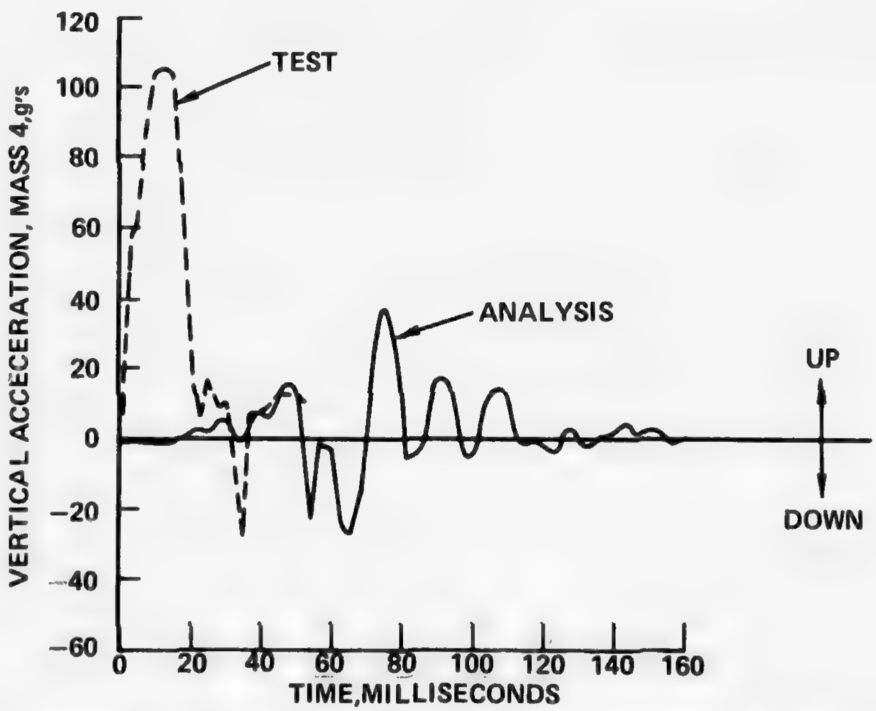


Figure 50. Cabin Floor Vertical Acceleration (Airplane A)

In Figure 49, the first two sharp peaks at 51 and 69 milliseconds result from the bottoming of internal beam 4-6. If the peak acceleration values at these two points are disregarded, the peak acceleration then becomes 43 g's longitudinally. It appears that the restiffening process for beam 4-6 is modeled too abruptly; a more gradual restiffening would lower these peaks to substantually less than 20-30 g's. If this were done, the envelope of the resulting responses would be about 30-40 g's peak with a duration of 100 milliseconds, which is in reasonable agreement with the data contained in Reference 12. The restiffening element type used for beam 4-6 is a standard NP = 9 curve (see section 4.4.6), and at present is internally coded such that the bottoming stiffness is equal to the linear stiffness of the element. Furthermore, the element behavior is similiar to an NP = 8 curve until bottoming occurs. The results of the airplane A comparison between test and analysis indicate that these limitations are too inhibiting. Consequently, the coding for this type of curve will be changed for the Task II effort to allow the user more flexibility in modeling this type of behavior. In particular the user will be able to define as input data the post-failure load-deflection behavior and the stiffening after structural confinement occurs.

The vertical acceleration at mass 4 (Figure 50) indicates a peak acceleration of approximately 38 g's with a long term response of approximately 70 milliseconds (40 to 110). The vertical acceleration pulse is in response to a longitudinal impact, thus it is difficult to relate this data to that given in Reference 12 which describes a vertical response to vertical impact. In that situation the Reference 12 data indicates a peak acceleration of 48 g's for 54 milliseconds duration.

The responses noted in Figures 49 and 50 are indicative of structure responding with a frequency in the 50-60 Hz range. The type of structure used in general aviation aircraft fuselage design is relatively light and stiff and may very well respond as shown by the analysis. It is also important in the evaluation of occupant survival to recognize that the occupant responds in a low frequency mode (6-12 Hz.). Thus pulses with frequencies above 25 Hz. have little effect on the occupant.

5.5.2 Airplane B Comparison

The Airplane B crash sequence is depicted in Figure 51 from initial impact (time = 0) to final position (time = 1.66 seconds). The modeling of the initial impact is performed for the first 80 milliseconds for the airplane positions shown in Figure 51 (a) and 51 (b). For the second impact, the sequences shown in Figure 51 (e) and 51 (f) are used. In the initial impact the ground is modeled with a 90 degree slope in the local region where the forward fuselage impacts. The forward fuselage has two external springs, one along the longitudinal axis of the airplane, and the other normal to the airplane longitudinal axis. Both external springs emanate from the engine mass (mass 11, Figures 37, 38) and represent the characteristics of the confined terrain deformation and spinner and cowl structure crushing. While the external spring is symbolized by a point contact it in fact represents a much broader area of contact. In this particular case, both the contact area and the region making ground contact change as the airplane rotates about the nose. The analytical model reproduces the initial crushing of the forward section of the fuselage with the longitudinal spring and also the subsequent contact of the upper cowl with the top of the slope as the airplane rotates over onto its top side. The analytical results show that the upper engine mount buckled. As stated in Section 5.3.2.4, the upper left engine mount failed during the test. However, since this mount had been previously repaired, the actual strength of the mount is not known. Outside of extensive damage to the upper cowl and hopper skins during the test, no other damage or failure was noted that could be attributed to the initial impact. In this respect the analytical model results agree with the test results.

Table 17 presents a comparison of analytical and test results for the initial impact of the forward fuselage section with the terrain. The test results are based on analysis of the motion pictures taken during the test. The film analysis is based on a 24 frame/second film speed. This film speed provides only one frame of data for every 40

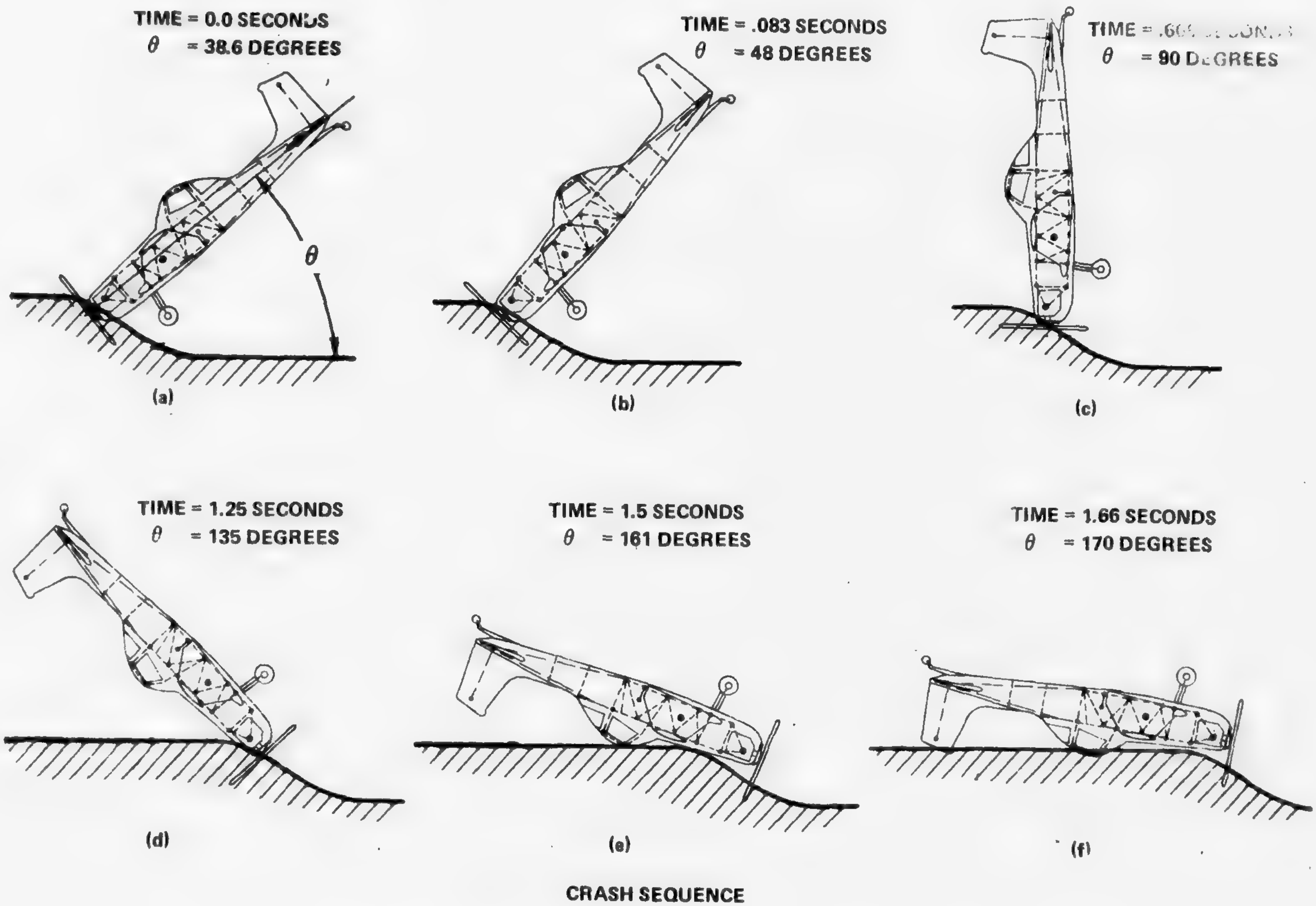


Figure 51. Crash Test Sequence of Airplane B as Determined from Photographs

milliseconds of motion, which is an order of magnitude slower than normally used in crash analysis. Normally, if available, 200 to 500 frame/second film speed is used to determine the details of a crash test. The results of the film analysis for the test sequence is presented and described in Appendix C. From Table 17 it can be seen that the rigid body rotational motion of the airplane is depicted with good accuracy (less than 1.5 percent) when compared to the results of the test film analysis for the 40 milliseconds involved in the initial impact. The energy that is absorbed, is mostly in crushing and friction. The kinetic energy obtained from the analysis is within 8 percent of the estimated kinetic energy at 40 milliseconds. At approximately 70 milliseconds after the impact the analysis indicates a buckle failure of the upper engine mount. At this time the c.g. longitudinal acceleration (average of masses 5, 6, 7 and 8, Figure 38) is computed to be 18.4 g's which is higher than the test peak value of 11.8 g's. Higher c.g. airplane axis vertical accelerations (20 g's) noted in the test results are not obtained by the analysis. The analysis shows vertical acceleration values less than the longitudinal results. This situation seems appropriate considering the orientation of the airplane for the first 80 milliseconds. As the airplane rotates onto the overturn structure (Figure 51 (c) and 51 (d)) higher c.g. airplane axis vertical acceleration may occur. At this point the energy absorbed by the airplane structure and ground obtained from the analysis is substantially higher than indicated by the data from the film analysis, although overall rotation of the airplane is within 1.5 percent of the estimated test value. It would appear that the test results, if adequate accuracy is assumed, would indicate closer agreement in energy and less agreement in motion than shown. The lack of definition of acceleration pulses (shape, duration and phasing) from the test results makes it difficult to quantify the comparison between analysis and test beyond the type and extent of structural damage and airplane motion.

The analytical results are influenced by the manner in which the deformation of the terrain is modeled using external springs. If the ground contact surface were concrete instead of soft dirt, there would be no

TABLE 17. COMPARISON OF AIRPLANE B ANALYTICAL AND TEST RESULTS FOR THE INITIAL IMPACT CONDITION

	Test	Analysis	Percent Difference (a)
Initial Rotation, θ (Degrees)	38.6	38.6	-
Initial Rotational Velocity, $\dot{\theta}$ (Degrees/Sec.)	106.	106.	-
Rotation, θ, at Time = .040 Sec. (Degrees)	42.8	42.7	.23
Kinetic Energy prior to Impact, Time = 0 (in-lbs)	2.611×10^5	2.607×10^5	.15
Kinetic Energy at Time = .040 Sec. (in-lb)	2.42×10^5	2.234×10^5	7.7

(a) (Test Value - Analytical Value) X 100/Test Value

TABLE 18. COMPARISON OF AIRPLANE B ANALYTICAL AND TEST RESULTS FOR THE TURNOVER INVERTED IMPACT

	Test	Analysis	Percent Difference (a)
Initial Rotation, θ (Degrees)	162.	162.	-
Initial Rotational Velocity, $\dot{\theta}$ (Degrees/Sec.)	89.	89.	-
Rotation, θ, at Time = .040 Sec. (Degrees)	165.7	165.6	0.06
Change in Rotation, $\Delta\theta$, at Time = .040 Sec. (Degrees)	3.7	3.6	2.7
Kinetic Energy Prior to Impact, Time = 0 (in.-lbs.)	7.19×10^4	7.106×10^4	1.17
Kinetic Energy at Time = .040 Sec. (in.-lbs.)	5.18×10^4	5.901×10^4	-13.9

(a) (Test Value - Analytical Value) X 100/Test Value

appreciable interaction between the ground and the structure. The analysis provides for the structure to penetrate the earth as much as 10 inches, wherein the earth is modeled softer than the structure. Thereafter the spinner and cowl structure influence the stiffness of the external spring that is used. The interaction between the terrain and the structure is difficult to define, which is further complicated by the fact that the area of contact is changing as the airplane penetrates and rotates. Analytical studies described in Reference 4 in which program KRASH was used to assess the effect of load-deflection variations on the response indicate that the results are most sensitive to the modeling of structure wherein confined crushing takes place. Generally, when crushing occurs the stiffness of the structure (or terrain) increases rapidly as it is compressed.

The impact of the turnover structure with the ground is modeled as depicted in the sequences shown in Figure 51 (e) and 51 (f). For the second impact, Figure 51 (e) represents the airplane position at time zero. In this condition, external springs are applied at masses 13, 14 and 25 as shown in Figure 38 (masses 24, 25, 26, 27, and 44, Figure 37). From Table 18 it can be seen that the analytical results compare favorably with test results for the period of time over which the high speed film could be analyzed. The rotation and the kinetic energy obtained by analysis are shown to be within 2.7 percent and 13.9 percent, respectively, of the test results obtained from film analysis. The analysis further shows that at 80 milliseconds after time zero, for the inverted impact, the kinetic energy has been reduced to approximately 23 percent of the kinetic energy available in this impact. The analysis further indicates that failure of the forward turnover structure, member 6-13, Figure 38 occurs. The test results indicate that a failure of the forward structure occurred during the test. While test data is not available for making a quantitative evaluation of cabin volume change, the films of the test and the photographs of the post test airplane condition (see Figure 31), indicate that little or no cabin volume change occurred which is consistent with the results of the analysis.

In addition to providing data for assessing the capabilities of the analysis to predict the behavior of an airplane during a multiple impact with large rigid body rotations, the tests also provide data concerning airplane/soil interaction. The test and analytical results agree in that the major energy absorption occurs in the action of the ground and the structure in contact with the ground. The lack of distortion of structure and minimal structural failure indicate very little (almost negligible) dissipation of energy as a result of permanent strain.

The analysis of this crash test, as well as the airplane A crash test, indicates that estimating the proper terrain representation, other than hard surfaces such as concrete and asphalt, is difficult because of the lack of terrain and airframe interaction data. While KRASH has provisions (external linear and nonlinear springs, generalized impact surface and ground friction) to utilize available terrain data, it should be recognized that terrain and airplane interaction is a complex phenomenon, which at best can only be approximated in KRASH at this time.

Of interest is the economics of running small models, if appropriate. Table 19 shows a comparison of results for the 43 mass and 24 mass models used for the initial impact. Since the crash in this particular case is symmetrical,the smaller model can be used to an economic advantage, if the accuracy of results is acceptable. As can be observed in Table 19 the results agree within 6 percent while the larger model requires more than twice the time (and cost) to perform the same analysis.

TABLE 19. COMPARISON OF RESULTS FOR THE 43 MASS AND 24 MASS AIRPLANE B MODELS

	24 Mass 37 Member Model (a)	43 Mass 80 Member Model (a)	Percent Difference (b)
Incremental Rotation (Degrees)	4.12	3.90	-5.6
Kinetic Energy (in.-lbs.)	2.23×10^5	2.187×10^5	-2.0
External Spring Deflection (inches)			
Longitudinal	8.93	9.07	1.5
Vertical	7.00	7.42	5.7
Computer Time (hrs)	.0455	.097	53.1

(a) Time = .040 seconds

(b) (Large Model Value - Small Model Value)X 100/Large Model Value

5.6 ASSESSMENT OF PROGRAM KRASH

In addition to performing comparison studies between analytical and test data using two general aviation airplanes, other portions of the Task I effort directly and indirectly provide information for assessing the capabilities of program KRASH to assist in establishing the crashworthiness of general aviation airplanes. These related efforts include the determination of the general aviation industry's computer capability, improvements in the ease and cost of operating the program, as well as the availability of structural data and the methods to be used for obtaining data.

The comparisons of two different general aviation airplane configurations subjected to two probable accident conditions along with a previous correlation using full scale crash test data (Reference 3) and accident results (Reference 15) have shown that program KRASH can provide satisfactory data to:

- Facilitate an evaluation of occupant injury assessment by providing the floor pulse to the occupant seat, describe structural deformation in and around the occupiable region, and provide a Dynamic Response Index (DRI) reading,

- Meet the general aviation airplane design requirements by providing multidirectional force, acceleration, velocity and deflection data,

- Account for large nonlinear behavior of different types of structure including failure modes, loss of structure, and an evaluation of member directional stresses,

- Treat probable crash conditions taking into account impact velocities, attitude, angular rates, terrain and position of the aircraft relative to the terrain,

- Describe different general aviation airplane configurations including low-wing, high-wing, single-engine and twin-engine types,

- Simulate significant portions of a crash wherein multiple impacts are involved, and

- Describe the temporal and spatial distribution of energy throughout the crash including mass kinetic and potential energy, member strain and damping energy and structural crushing and the ground friction associated energy.

In addition KRASH has been modified to standardize many parameters, simplify imput data requirements and clarify output data with the use of English symbols where appropriate. All modifications are briefly described in Section 4 of this report and comprehensively detailed in Section 1 of Reference 13.

The program has demonstrated its capability to treat a wide variety of vehicles and crash situations. However, as is the situation with any analytical approach, the accuracy that can be achieved depends to a large extent on the understanding of the program limitations and the manner in which the program is utilized. Fundamental to using KRASH effectively is to recognize that the program is best at describing vehicle general structural behavior and may employ simplified representation of large structural sections in some areas. While the program allows for a definition of a wide range of nonlinear behavior, it only approximates

post-failure behavior. However, the results of sensitiveity studies using KRASH are described in Reference 4, and they show that acceptable accuracy commensurate with the requirements for this type of analysis can be obtained with this approach as long as the peak failure load and deflection are satisfactorily represented.

Although program KRASH provides inputs to help assess occupant's chances of survival it does not, by itself, provide a measure of more than one injury type (DRI) which is limited to describing vertebrae compression. The program does supply a multidirectional pulse at the seat attach point along with an overall description of the behavior of the occupiable space for use in a detailed occupant, seat and restraint system model that would provide potential injury information.

As described in the modeling of the overturn accident, this type of crash would normally require an order of magnitude more computer time than a normal crash sequence. Considering that very little structural damage occurs and that no significant loads act on the occupants during most of the sequence, the use of a numerical integration scheme with a fine integration interval is a very inefficient approach. Consequently, KRASH, complemented with rigid body analysis, should be used to model only significant portions of a crash.

In some respects the program is limited by the availability of data. This limitation applies to all current analytical techniques. In particular, it is difficult to substantiate combined loading and/or unloading and ground-structure interaction, because of the lack of measured data in these areas, for many types of situations that apply to airplane structure and crash conditions. If measured data and/or proven analytical techniques become available, they can be readily used with program KRASH. As noted in Reference 4 the use of simplified techniques to obtain data as input to KRASH are practical.

SECTION 6

TASK I RESULTS

The following discussion presents a summary of the results of the Task I effort.

6.1 REVIEW AND EVALUATION OF GENERAL AVIATION AIRPLANE CHARACTERISTICS

A review and evaluation of 61 light fixed-wing airplane models, produced by the major domestic general aviation airplane manufacturers was performed. The evaluation takes into consideration airplane configuration, usage, operational characteristics, and structural characteristics.

Included in the review and evaluation of general aviation airplane characteristics are:

- a matrix of airplane configuration, maximum takeoff weight and usage,
- a description of structural design characteristics of current general aviation airplanes,
- a description of the various general aviation airplane types, and
- a categorization of airplanes as a function of configuration, maximum takeoff weight, stall speed, cruise speed, usage and accommodations.

The results of the study show that:

(a) There are four basic airplane configurations; single-engine low-wing, single-engine high-wing, twin-engine low-wing and twin-engine high-wing.

(b) With the exception of the agricultural airplane most airplanes have multiple uses.

(c) There is a trend, insofar as usage, accommodations, weight and speed characteristics are involved which leads to a logical grouping of the airplanes by categories.

(d) While there are many manufacturers and airplane models and the design details of the structure may vary, there are only two basic structural designs: monocoque and tubular.

A plot of airplane maximum cruise and flaps down stall speeds as a function of maximum takeoff weight for the different airplane models reviewed during this effort, is presented in Figure 52. The envelope reflects a practical range of velocities that would encompass most crash conditions which will aid in establishing the crash environment.

6.2 REVIEW AND EVALUATION OF ACCIDENT DATA

Accident data from CAMI, NTSB and referenced reports were obtained, reviewed and evaluated. Included in the accident evaluation are:

- results of 18 CAMI accident records showing (a) the frequency of occurrence by phase of operation, type of accident, angle of impact roll/yaw attitude, and terrain, (b) the distribution by degree of cabin damage, structural damage, and injury types and (c) the occurrence of seat and seat belt failures and occupant impact with controls and instrument panels;

- the description of a computer program, developed during this task, to sort and process selected pertinent crashworthiness accident data from NTSB data tapes; and

- results of 1971 through 1973 NTSB accident records, encompassing 8491 accidents, obtained from the accident computer program employing the airplane categories established during this task.

The results of the NTSB accident data evaluation indicate that:

(a) The impact angle in a crash is predominantly ≤ 45 degrees.

(b) Stall, collisions with ground/water and collisions with obstacles are the prevalent types of accidents which result in serious or fatal injuries.

(c) In accidents wherein injuries are involved, light weight single-engine airplanes have a greater number of stall accidents than accidents involving collision with ground/water or obstacles. Conversely, heavier weight single-engine and twin-engine airplanes experience more accidents involving collision with the ground.

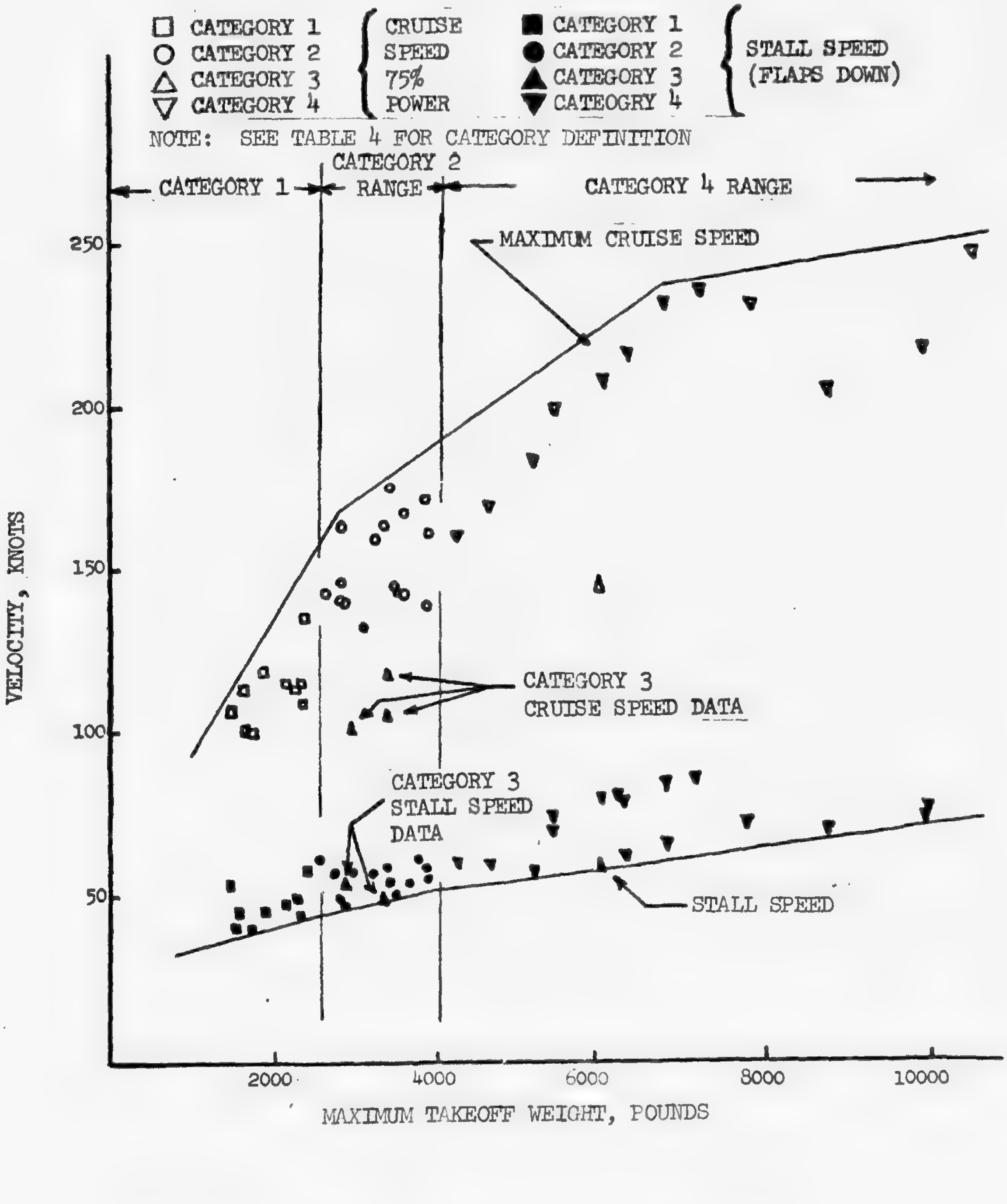


Figure 52. Operational Velocity/Weight Envelope for Current General Aviation Airplanes

(d) The personnel involved in agricultural type airplane accidents, wherein injuries occur, experience less fatalities per occupant in all types of accidents.

(e) The ratio of fatalities to number of occupants, for accidents involving injuries, is generally lower for the single-engine airplane than the corresponding ratio for twin-engine airplanes for the same type of accident.

6.3 MATHEMATICAL MODELING REQUIREMENTS

Seven members of the General Aviation Manufacturer's Association (GAMA) were sent an inquiry regarding their current and anticipated computer capability. Their responses indicate that the industry computer capability as a whole will, by 1977, be sufficient to utilize reasonably large ($\approx$500,000 bytes) computer programs. However, based on the lack of current standard plotting capability within the industry, no attempt should be made to have a plot package compatible with any particular routine.

Based on the results of the review of industry computer capability and evaluation of general aviation airplane designs and accident statistics, a mathematical model, to be of benefit to the industry, should have the capability described in Section 4.2.

A brief description of program KRASH, which is the basis of the analytical method for the development of a general aviation airplane mathematical computer program is presented. The modifications to program KRASH to improve its modeling capability, add flexibility and versatility, and to facilitate its usage by the industry are described. Program KRASH, as modified for this program, contains many features not available in other current analytical techniques. A summary of program KRASH modifications, briefly stating their advantages and noting associated current restraints is presented in Table 20. The restraints do not inhibit the program's use, but serve to indicate to a potential user that program KRASH, like any analytical procedure, has certain limitations in its application. An understanding of the program's capabilities will enhance its usage and, consequently, the benefits that can be obtained therefrom.

TABLE 20. MODIFICATIONS TO KRASH

Modification	Advantage(s)	Current Restraint
Generalized Surface	• Adds modeling flexibility and versatility and requires only one additional input term • Treats slope angle > 0° and < 90°	• Surface can only slope upward • Surface is rigid
Standard Non-Linear Curves	• Five (5) standard load-deflection shapes • Ease of input • Representative of structural behavior • Facilitates parametric studies	• Approximate technique • Requires user selection based on available guidelines
Member Directional Stress	• Detects potential failure for selected members • Tests against two (2) yield criteria	• Primarily of use in linear range • Excludes effects of stress concentrations and detail design practices
Cabin Volume Change	• Detects potential danger to occupants in occupiable region	• Describes motion of mass points only
Linear Stiffness Matrix	• Input E, A, G, I_y, I_z member properties and program computes member stiffness matrix • Doesn't alter basic response computations • User still has option to input member stiffness, if available • User can identify joint attachment • Reduces input to one card per member instead of 6 cards per member	• Each internal member is represented by only a 6 x 6 stiffness matrix which is related to a set of properties (E, A, G, I_y, I_z, length)
Model Parameter Data	• Program computes from the input data: (a) vehicle mass and inertia properties, (b) location and position relative to the ground contact point and (c) element stiffness, frequency and damping values	• Element frequency and damping values are based on KRASH formulation and are "relative" terms. Guidelines for interpreting this data are available
Plow Effects	• Represents drag force as a constant average force acting over a time span • Can use ground friction with external springs to model plowing effects	• Depends on the availability of applicable data • Detailed interaction with soft earth not modeled
Acceleration Pulse	• Includes provisions for specifying an acceleration pulse (location, direction, time history) acting on a mass or masses	• Restricted in number of masses to which the pulse can be applied
Damping Terms	• Standard member damping internally coded can reduce input card to 1 for whole model instead of 1 for each member • Revised damping force computation reduces the chance for instability	• Damping is only related to percent critical structural values. Incompatible damping value and/or integration interval can cause numerical instability. "User's Manual" provides guidelines for proper selection of values
Miscellaneous Coding Changes	• Treatment of beam longitudinal elongation is improved • Computation of external spring forces and energies is improved • Relationship between coupled force moment terms is preserved	• Nonlinear relationship for coupled forces and moments depends on nonlinear characteristics which is input data
Input and Output Format	• New format is more consistent and uniform • Expanded print of input and output terms to facilitate understanding and usage • Substantially less input data cards required (>2/3 reduction can be achieved)	

6.4 ASSESSMENT OF KRASH

KRASH, as modified during this effort, is used to model two different general aviation airplane models for which controlled crash test data is available. The data was obtained from controlled crash tests which represented a stall spin and an overturn accident. The assessment of KRASH encompasses the following.

- Descriptions of the two crash tests including purpose, sequence, instrumentation, photographic coverage, failures and photographs of the airplanes in the pretest and post test conditions.

- Descriptions of the mathematical models that are developed to represent each of the airplanes for the particular crash conditions.

- Comparisons of test and analysis results were performed for the following three impact conditions.

  (a) 45 ft/sec longitudinal velocity impact into a 45 degree dirt barrier

  (b) c.g. velocity of 19.5 inches/second (down), 259 inches/second (forward)pitch attitude of 38.5 degrees (nose down)

  (c) c.g. velocity of 102 inches/second (down), 45.5 inches/second (forward)
  pitch attitude of 19.6 degrees (nose down in inverted position)
  pitch rate of 89.4 degrees/second (nose down in inverted position)

The results of the assessment indicate that Program KRASH meets the general aviation airplane crash analysis requirements as noted in Section 4.2. In particular, program KRASH has been shown to be capable of defining:

- spatial and temporal energy distribution including mass kinetic and potential, member strain and damping, structural crushing, and ground friction;

- large nonlinear behavior into the post-failure region including occupiable cabin deformations;

- acceleration pulses at the floor in regions where occupants are located for the purpose of determining occupant response using an available occupant-seat-restraint system math model;
- forces, accelerations, velocities and deflections resulting from multidirectional impacts;
- structural behavior for a wide range of structural element types associated with general aviation airplane design;
- large motion rigid-body behavior wherein ground contact forces can be defined; and
- mathematical model requirements for two different airplane configurations (high-wing, low-wing).

Program KRASH has also been shown to have some limitations with regard to modeling certain impact conditions such as terrain-structure interaction and coupling of nonlinear loading and unloading behavior. The limitations associated with KRASH are at present applicable to all other analytical techniques. In some instances the development of additional analytical techniques or the acquisition of additional experimental data may alleviate these limitations.

Table 21 summarizes program KRASH's capability with regard to meeting the mathematical model requirements. Included are pertinent comments that indicate areas wherein the user should have a good understanding of KRASH's limitations with regard to input data as well as the output that is obtained.

TABLE 21. ASSESSMENT OF KRASH'S CAPABILITY

Requirement	KRASH Capability	Comments
Assessment of Occupant Survival	o Provides acceleration pulses (magnitude, shape, and duration), DRI, volume change and penetration data o Describes structural behavior which can influence occupant survival	o Present occupant, seat and restraint systems are not modeled rigorously o Detail volume change is dependent on the number of masses representing a region o DRI is a measurement of only one type of injury
Multidirectional Forces	o Provides accelerations, forces, velocities and displacements for translations (3) and rotations (3)	o Difficult to obtain test data to substantiate combined loading interaction
Structural Behavior, Deformation and Failure	o Represents linear and nonlinear load-deflection characteristics o Provides member directional stresses o Provides forces, velocities, and deflections o Represents crushing of structure and friction due to ground forces o Provides temporal and spatial energy distribution	o Approximate representations of post-yield load-deflection behavior o May require simplified representation of large section structural characteristics o Stresses alone are inadequate measures of structural behavior and/or failure
Airplane Configurations	o Treats all configurations including single-engine, twin-engine, low-wing, high-wing, and light and heavy-weight airplanes o Treats welded tube and semi-monocoque fuselages, tubular and keel engine mount designs, and cantilever wing and tail units	o Obtains vehicle gross behavior, thus number and location of nodes are to be selected and represented based on suggested guidelines
Multiple Impacts	o Determines significant portions of a crash utilizing the generalized surface routine to represent contact surface	o Not economical for performing entire crash sequence (supporting rigid body analysis can define subsequent impact conditions)
Crash Environment	o Can treat probable crash conditions (velocity, impact angle, attitude, initial rates) and terrain with the use of external springs, plow term, generalized surface and specification of initial conditions	o Depends on available data regarding terrain characteristics and effects of interaction with structure o Capabilities would be improved with addition of a flexible ground surface
Practical and Economical	o Utilizes available data and approximates structural behavior o Emphasizes peak force transmittal and energy absorption o Performs crash analysis using numerical integration o Uses English symbols to define input and output o Contains standardized data o Particularly effective in preliminary design	o Potential refinements include a) variable time step integration scheme b) symmetrical model coding c) restart capability d) additional standardization of data e) increase modeling flexibility

SECTION 7.0

CONCLUSIONS

1. Based on the results of the correlation studies made, program KRASH, modified as described in this report, is a satisfactory method of performing structural crashworthiness analysis of general aviation airplanes during probable accident conditions.

2. Program KRASH is most appropriate for use during preliminary design, wherein it is desired to determine approximate airframe response to crash conditions to aid in incorporating crashworthy features in an economical manner.

3. The crash environment is influenced by airplane operating characteristics such as usage, stall and cruise speed, and mode of operation; and, by airplane configuration such as weight, and number of engines.

4. Typical crashes involving light fixed-wing aircraft indicate that the behavior of structure in some regions of the aircraft, during a crash, can have a significantly greater influence on occupant survivability than other regions. Consequently, simplified representations of structure in noncritical regions can be used in crash analysis.

5. A computer program developed by Cessna provides the basis by which NTSB accident data can be compiled and evaluated with regard to airplane configuration and/or usage as a function of accident types, terrain, injuries and/or fatalities to aid in determining crash environment design criteria.

SECTION 8
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APPENDIX A
ACCIDENT COMPUTER PROGRAM

A.1 OBJECTIVE

The purpose of this program is to summarize and to provide individual record print-outs of selected fields of selected makes and models of aircraft contained on the National Transportation and Safety Board (NTSB) data files for the years 1971, 1972, and 1973.

A.2 GENERAL INFORMATION

Minimum System Requirements

Core - 92K
Disk Space - 3800 tracks of IBM 3330
Tape Drives - 3
Printer - 1 IBM 1403
Card Reader - 1
Paper - 14" x 11"
Carriage Tape - 88 lines/page
Language - Cobol level G
Operating System - DOS/VS
Machine - IBM 370/158
Code - EDCDIC

Typical Run Time

MTSB0002 - 3 Minutes/Tape
SMTSB02 - 2 Minutes
1325020D - 12 Minutes
MTSB0001 - 2 Minutes
Print Time - 15 Minutes/Tape (Approximately 15000 lines/tape)

Manuals and Input Files

Before this program is exercised the user must acquire the manuals listed below:

Manuals

For a complete description of the input record, refer to the NTSB documents numbered 1, 2 and 3 below. Item number 4 refers to a manual associated with an NTSB program and data tape.

1. Tape Positions and Subject Matter, Aircraft Accident Files, U.S. Civil Aviation.

2. Manual of Aircraft and Engine Code Classifications.

3. Manual of Code Classifications, Aircraft Accidents & Incidents.

4. User Instructions ADP Programs - Automated Aircraft Accident and Incident Information System.

The NTSB files and manuals may be obtained by writing:

National Transportation Safety Board
Department of Transportation
Washington, D.C. 20591

You must ask specifically for each of the items listed above. If you have a problem interpreting the manuals, call:

Dave Kelly
1-202-426-3976

in Washington, D.C. He and his office have been very helpful in Cessna's work with the files.

Input Files

Full Print Header Files

A tape file which contains the Full Print Headers to be used by MTSB0001.

Record Layout for the Accident Record

This file resides on our source statement library and is copied into MTSB0002 and MTSB0001.

Accident Data Files

These files contain the actual accident record. The years 1963 thru 1974 are currently available.

In summary, the input which must be available to these programs as they exist now is as follows:

1. Accident Data Files - input to MTSB0002.

2. English Meaning Header File - input to 1-325-020-D.

3. Data Record Book on a Source Statement Library - Input to MTSB0001 and MTSB0002.

How to Execute the System

Step 1 - Obtain a copy of the program, Job Control and Data Tape from Lockheed Aircraft.

This tape will contain the programs necessary to process all the input data, the job control required to execute the programs and the Full Print Header File in that order. See Section A.8 for a discussion of this tape.

Step 2 - Compile and catalog all the programs on the tape and put the Accident Data File input record description on your source statement library.

Step 3 - Make a magnetic tape labeled "NTSB Headers" as noted in the JCL listing which contains the Full Print Headers.

Step 4 - Execute the system. Mount the input tapes as called for in the machine room setup sheets. You may mount the Accident Data Files in any order. It is suggested that the user write a small program to read each accident data file before processing the entire job because the tapes have been known to produce data checks.

If a user should find it necessary to change the screening in the programs to meet objectives different than those of the existing system, certain program changes will be necessary. See the individual program description in this report for information on how to carry out changes.

A.3 PROGRAM DESCRIPTION

Program MTSB0002 - Record selector by make and model code and model number.

This program selects accidents from as many NTSB accident data files as desired and writes them to a separate tape file. A tape file is selected to eliminate the necessity for rerunning this program each time a run on MTSB0001 is made.

It should be noted that the table for selection of airplanes is built directly into the program. Any user would need to change the table if years other than 1971, 1972, 1973 or 1974 are to be used to satisfy different requirements. The table, named MK-MOD-01, must be in ascending order Col 46 thru 56. The table content is:

Card Col	Content
46-48	Make Code
49-50	Model Code
51-56	Model Name

See a current manual of Aircraft and Engine Code Classifications for a complete description of the content.

It is suggested that a user write a program, to search the accident data tapes on the make and model codes and model numbers which are needed and let the program punch the table. This will prevent the lengthy research necessary to determine exactly how the model name was entered in the accident records. The selected records should be listed, sorted, duplicates eliminated, then punched. The list can be edited and selected models may be removed from the table of punched cards. This, then, will be the final table used in MTSB0002. All the accident data files to be processed by MTSB0002 should be used in the creation of the make and model table. It should also be noted that the model names contain some error. For example, Cessna has Model 150 names entered as 15Ø and 150. Also, the names may not always be left justified in the field. By writing a program to pre-edit and punch the three fields, all the fielding and punching errors can be easily found and used.

Input

Selected NTSB accident data tapes. As of this writing 1963-1974 are available with 1975 soon to be released. See Appendix A for sample input record.

Output

A tape file which contains NTSB accident records is selected by make and model codes and model name.

Console Messages	Operator Response
IF THIS IS THE LAST FILE ENTER LAST IF NOT THEN MOUNT NEXT TAPE AND ENTER NEXT	Enter NEXT or Last
YOU GOOFED REENTER YOUR RESPONSE	Enter Correctly spelled response

Program SMTSB002

This is a sort which sorts the selected records on make and model code. See the SORT FIELDS record in the sort for exact fielding and sort hierarchy.

Input

Tape created by MTSB0002 which contains selected accidents.

Output

Tape file which contains sorted accident records.

Program 1-325-020-D

This program creates a direct access Full Print Header file to be used by MTSB0001.

Input

Tape file which contains the English meaning Full Print Headers. These headers are on the program and data tape.

Output

A direct access file of Full Print Headers.

Program MTSB0001

This program further selects accidents based upon the following criteria:

a. Certain Aircraft Types.

b. Certain Major Operational Phases.

c. Certain Minor Operational Phases within Major Phases C, D, or E.

d. Terrain Types

e. Cause - Factors

If the aircraft accident is of type D, E, F, L, P, R, 0, 1, 2, 4, 5 and 7, the accident is not processed further. These types are in the variable named TYPES - 77 and moved to TYPES - 01.

The major operational phase summary at top of Page 2 summarizes all major phases. However, thereafter, if the major phase is not Code C, D or E, i.e., takeoff, inflight or landing respectively, the information is not tallied and the accident is rejected entirely except for its tally in total accidents surveyed and the grand total accidents surveyed.

All minor operational phases are surveyed except the 'Øther' categories under major phases C, D and E.

If the terrain type, cause-factors or certain minor phases were not acceptable, processing continues to obtain tallies in other applicable areas.

Input

A file which contains the NTSB records is selected and sorted by MTSB0002 and SMTSB002 respectively.

Output

Printed output which consists of:

1. Individual record print-outs if the accident reported

   a) impact angle
   b) impact velocity
   c) stopping distance
   d) seat failure
   e) seat belt failure
   f) attitude at impact

   This does not constitute a complete record print-out, only selected portions.

   There are no codes printed. The information is either taken directly from the record or the code is used to retrieve a header from the header file created by program 1-325-020-D.

2. Five pages of summary data which summarizes a make and model for all years are entered into MTSB0002.

   The discussion of each page that follows deals only with those outputs which are not self-explanatory.

   First Page Summary - General Information

   The aircraft model is an aircraft model code because the summary is for all selected specific models in all the years processed.

   The total number of accidents surveyed is a count of all those accidents, in a make and model code, on the input file.

   The total applicable accidents surveyed is a count of those accidents of an acceptable type.

   The total number of occupants is a summation of all the aircraft occupants in the applicable accidents.

   The average number of occupants is the rounded quotient of the division of number of occupants by number of applicable accidents.

   The sum of all entries in the Totals of Seriousness of Injuries table should equal the total number of occupants.

Second Page Summary - Flight Conditions

The major phase summary at top of the page summarizes all accidents on the input file of acceptable type.

The second summary on minor phase of operation summarizes only upon meeting type, major phase and minor phase requirement. No 'Other' category minor phases were summarized here. Which means that the total number of accidents will always be equal to or less than the total applicable accidents.

The third summary on types summarizes only upon meeting type and major phase requirements. The total number of accidents here should equal the total applicable accidents.

Third Page Summary - Impact Conditions

The 90+, 120+ and 360+ include 90, 120 and 360 respectively in their tallies.

The occupant injury table cannot be depended upon to record all injuries because not all the accident records contain an entry in the damage severity field. Summation was done only if a damage severity was recorded.

Fourth Page Summary - Aircraft Cabin Accommodations

The Impact Area summary percentages should total to nearly 100%. If they do not, then it can be attributed to round-off error. The list is sorted in descending order by percent.

Program Areas Which a User May Wish to Change

All the major operational phases are built into the procedure division. The program areas which must be changed are:

1. The page layout for Page 2 which begins at Statement Number 055400. This will probably change the number of array elements in Statement Number 065300.

2. The screen is at Statement Number 105200.

3. If the number of array elements for Page 2 has changed then the PERFORM at Statement Number 213700 must be changed to equal the number of array elements used in No. 1 above.

he minor phases used for screening are contained in an array named OP-PH-01. The codes contained in this array must be in ascending order. A change in the number of codes means that this OCCURS clause at Statement Number 088600 must change and also the number in the MOVE in Statement Number 168900.

The terrain types are in a 77 level data named TERRAIN - 77. The items in this array must be in ascending order. A change in the number of items means the picture size must change in Statement Number 019700 and the values in Statement Number 024000, 040900, 041000, 186300, and 186400 must change to equal the picture size in 019700.

The cause-factors are contained in an array named CAUSE-FACTOR-01. No change need be made in the occurs clause until more than 500 cause-factor codes are used. Currently 494 are used. It should be noted that due to a few errors in the original key punching of the table, certain duplication of codes were introduced in order to avoid repunching the entire table. This will cause no problem in the searching of the table. If the number of array elements is changed then MOVE in Statement Number 191600 must change to correspond.

A.4 LIST OF JOB CONTROL

```
* $$ JOB MTSB001                           SUMNER
* $$ PRT 0,4814,1,,1000000000000000000000C0076
// JOB MTSB0001                    SUMMARIZE AND LIST SELECTED AIRCRAFT
// OPTION CATAL,SYM
   PHASE TMTSB001,*
[illegible]
/*
// LBLTYP NSD(04)
// EXEC LNKEDT
/*
// EXEC FGPPAGE
SUMNER
/*
/&
* $$ EOJ
// JOB MTSB0002        SELECT AIRCRAFT FROM NTSB FILES
// OPTION CATAL
   PHASE TMTSB002,*
// EXEC FCOBOL
/*
// LBLTYP NSD(04)
// EXEC LNKEDT
/*
// EXEC FGPPAGE
SUMNER
/*
/&
// JOB R325020D          FULL PRINT HEADERS TO DIRECT ACCESS DISK
// OPTION CATAL
   PHASE R325020D,*
// EXEC FCOBOL
/*
// LBLTYP NSD(04)
// EXEC LNKEDT
/*
// EXEC FGPPAGE
SUMNER
/*
/&
* $$ JOB MTSB0002         SELECT AIRCRAFT FROM NTSB FILES
// JOB MTSB0002
// ASSGN SYS018,X'T01'
// ASSGN SYS019,X'T02'
// LBLTYP NSD(04)
// EXEC TMTSB002
/*
// EXEC FGPPAGE
SUMNER
/*
/&
* $$ EOJ
// JOB SORT        SELECTED AIRCRAFT
// ASSGN SYS001,X'T03'
// ASSGN SYS002,X'T02'
// ASSGN SYS003,X'WK1'
// DLBL SORTWK1,'MTSB0001',72/001,SD
// EXTENT SYS003,,1,0,0019,1850
// ASSGN SYS004,X'WK2'
// DLBL SORTWK2,'MTSB0001',72/001,SD
// EXTENT SYS004,,1,0,0019,1850
// EXEC SORT
   SORT FIELDS=(82,5,BI,A),WORK=2
   RECORD TYPE=F,LENGTH=1600
   OPTION LABEL=(U,U,S)
   END
/*
// MTC RUN,SYS002
/&
* $$ JOB 1325020D        FULL PRINT HEADERS TO DIRECT ACCESS DISK
* $$ PRT 0,14P1,1,,10000000000000000000000056
```

```
// JOB 1325020D
// LBLTYP NSD(04)
// ASSGN SYSLST,IGN
// ASSGN SYS010,X'T01'
// TLBL SYS010,'NTSB HEADERS',,325020
// ASSGN SYS012,X'WK2'
// DLBL SYS012,'NTSB',69/200,DA
// EXTENT SYS012,,1,0,0019,1900
// EXEC R325020D
/*
// EXEC FGPPAGE
SUMNER
/*
// MTC RUN,SYS010
/&
* $$ EOJ
* $$ JOB MTSB0001       SUMMARIZE AND LIST SELECTED AIRCRAFT
* $$ PRT D,14P4,1,,10000000000000000000000056
// JOB MTSB0001
// ASSGN SYS018,X'T03'
// ASSGN SYS019,X'WK2'
// DLBL SYS019,'NTSB',69/200,DA
// EXTENT SYS019,,1,0,0019,1900
// ASSGN SYSLST,IGN
// LBLTYP NSD(04)
// EXEC IMTSB001
/*
// EXEC FGPPAGE
SUMNER
/*
/&
* $$ EOJ
// JOB CATALOG NTSBMSTR TO SOURCE LIBRARY
// EXEC MAINT
 CATALS C.NTSBMSTR
 BKEND C.NTSBMSTR
 BKEND C.NTSBMSTR
/*
// EXEC SSERV
 DSPLY C.NTSBMSTR
/*
// EXEC FGPPAGE
RENNEKE
/*
/&
```

A.5 PROGRAM LISTING

```
   1   IBM DOS AMERICAN NATIONAL STANDARD COBOL    VERSION 3 REL3.2  PP NO. 5736-CB2

CBL CLIST,LIBR=YES,SXREF
    000100 ID DIVISION.
    000200 PROGRAM-ID. MTSB0002.
    000300 AUTHOR.  J. A. SUMNER.
    000400 INSTALLATION.   THE CESSNA AIRCRAFT COMPANY.
    000500 DATE-WRITTEN.    9-20-75.
    000600 DATE-COMPILED. 04/09/76.
    000700 SECURITY.    NOT CLASSIFIED.
    000800 REMARKS.
    000900        THIS PROGRAM SELECTS CERTAIN AIRCRAFT FROM THE NTSB MASTER
    001000        FILES TO BE SUMMARIZED BY MTSB0001.
    001100 ENVIRONMENT DIVISION.
    001200 CONFIGURATION SECTION.
    001300 SOURCE-COMPUTER.      IBM-370.
    001400 OBJECT-COMPUTER.      IBM-370.
    001500 INPUT-OUTPUT SECTION.
    001600 FILE-CONTROL.
    001700        SELECT NTSB ASSIGN SYS018-UT-2400-S.
    001800        SELECT NTSB-TAPE ASSIGN SYS019-UT-2400-S.
    001900 DATA DIVISION.
    002000 FILE SECTION.
    002100 FD  NTSB
    002200        LABEL RECORDS ARE OMITTED
    002300        RECORDING MODE IS F
    002400        DATA RECORD IS NTSB-REC.
    002500 01     NTSB-REC COPY NTSBMSTR REPLACING REC BY NTSB-REC.
C   000270 01     NTSB-REC.                                                    RON
C   000280        02  F001.                                                    RON
C   000290            03  F00101        PICTURE 99.                            RON
C   000300            03  F00102        PICTURE XX.                            RON
C   000310            03  F00103        PICTURE XX.                            RON
C   000320        02  F002              PICTURE X(6).                          RON
C   000330        02  F003              PICTURE X(10).                         RON
C   000340        02  F004.                                                    RON
C   000350            03  FILLER        PICTURE X(5).                          RON
C   000360            03  F00401        PICTURE X.                             RON
C   000370        02  AF004    REDEFINES F004.                                 RON
C   000380            03  AF00401       PICTURE 99.                            RON
C   000390            03  AF00402       PICTURE XX.                            RON
C   000400            03  AF00403       PICTURE XX.                            RON
C   000410        02  F005.                                                    RON
C   000420            03  F00501        PICTURE X.                             RON
C   000430            03  F00502.                                              RON
C   000440                04  FILLER        PICTURE X(16).                     RON
C   000450                04  FC050201      PICTURE X.                         RON
C   000460        02  F006              PICTURE X(11).                         RON
C   000470        02  F007              PICTURE X(6).                          RON
C   000480        02  F008.                                                    RON
C   000490            03  FILLER        PICTURE X(9).                          RON
C   000500            03  F00801        PICTURE X.                             RON
C   000510        02  F009.                                                    RON
C   000520            03  FILLER        PICTURE XXX.                           RON
C   000530            03  F00901        PICTURE X.                             RON
C   000540        02  FILLER            PICTURE X.                             RON
C   000550                                                                     RON
C   000560                                                                     RON
C   000570        02  GEN-INFO.                                                RON
C   000580                                                                     RON
C   000590          03 F010             PICTURE X.                             RON
C   000600          03 F011             PICTURE XX.                            RON
C   000610          03 F012             PICTURE XXX.                           RON
C   000620          03 F013             PICTURE XX.                            RON
C   000630          03 F014             PICTURE XX.                            RON
C   000640          03 F015             PICTURE XX.                            RON
C   000650          03 F016             PICTURE X.                             RON
C   000660          03 F017             PICTURE X.                             RON
C   000670          03 F018             PICTURE X.                             RON
C   000680          03 F019             PICTURE X.                             RON
C   000690          03 F020             PICTURE X.                             RON
C   000700          03 F021             PICTURE X.                             RON
C   000710          03 F022             PICTURE X.                             RON
C   000720          03 F023.                                                   RON
C   000730              04  F02301      PICTURE X.                             RON
```

```
C          04  F02302        PICTURE X.                 RON
C        03 F024             PICTURE X.                 RON
C        03 F025.                                       RON
C          04  F02501        PICTURE X.                 RON
C          04  F02502        PICTURE X.                 RON
C        03 F026             PICTURE XX.                RON
C        03 F027             PICTURE X.                 RON
C        03 F028.                                       RON
C          04  F02801        PICTURE X.                 RON
C          04  F02802        PICTURE X.                 RON
C        03 F029.                                       RON
C          04  F02901        PICTURE X.                 RON
C          04  F02902        PICTURE X.                 RON
C        03 F030.                                       RON
C          04  F03001        PICTURE X.                 RON
C          04  F03002        PICTURE X.                 RON
C        03 F031.                                       RON
C          04  F03101        PICTURE X.                 RON
C          04  F03102        PICTURE X.                 RON
C        03 F032.                                       RON
C          04  FILLER        PICTURE X(4).              RON
C          04  F03201        PICTURE X.                 RON
C        03 F033.                                       RON
C          04  FILLER        PICTURE X(4).              RON
C          04  F03301        PICTURE X.                 RON
C        03 F034.                                       RON
C          04  FILLER        PICTURE XX.                RON
C          04  F03401        PICTURE X.                 RON
C        03 F035.                                       RON
C          04  FILLER        PICTURE X(13).             RON
C          04  F03501        PICTURE X.                 RON
C                                                       RON
C                                                       RON
C       02  EMGCY-COND.                                 RON
C                                                       RON
C        03 F036             PICTURE X.                 RON
C        03 F037.                                       RON
C          04  F03701        PICTURE X.                 RON
C          04  F03702        PICTURE X.                 RON
C        03 F038             PICTURE X.                 RON
C        03 F039             PICTURE X.                 RON
C        03 F040.                                       RON
C          04  F04001        PICTURE X.                 RON
C          04  F04002        PICTURE X.                 RON
C                                                       RON
C                                                       RON
C       02  WEATHER.                                    RON
C                                                       RON
C        03 F041             PICTURE X.                 RON
C        03 F042             PICTURE X.                 RON
C        03 F043             PICTURE X.                 RON
C        03 F044             PICTURE X.                 RON
C        03 F045             PICTURE X.                 RON
C        03 F046             PICTURE X.                 RON
C        03 F047             PICTURE X.                 RON
C                                                       RON
C                                                       RON
C       02  AIRPORT.                                    RON
C                                                       RON
C        03 F048             PICTURE X.                 RON
C        03 F049             PICTURE X.                 RON
C        03 F050             PICTURE X(5).              RON
C        03 F051             PICTURE X.                 RON
C        03 F052             PICTURE X(17).             RON
C        03 F053             PICTURE X(5).              RON
C        03 F054             PICTURE X.                 RON
C        03 F055             PICTURE X.                 RON
C        03 F056.                                       RON
C          04  F05601        PICTURE X.                 RON
C          04  F05602        PICTURE X.                 RON
C        03 F057             PICTURE X.                 RON
C        03 F058             PICTURE X.                 RON
C        03 F059             PICTURE X.                 RON
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           03 F060              PICTURE X(5).                                   RON
                                                                                RON
                                                                                RON
          02  ITINERARY.                                                        RON
                                                                                RON
           03 F061.                                                             RON
              04  F06101        PICTURE X.                                      RON
              04  FILLER        PICTURE X(20).                                  RON
           03 F062.                                                             RON
              04  F06201        PICTURE X.                                      RON
              04  FILLER        PICTURE X(20).                                  RON
           03 F063.                                                             RON
              04  F06301        PICTURE X.                                      RON
              04  FILLER        PICTURE X(20).                                  RON
                                                                                RON
                                                                                RON
          02  ACC-SITE.                                                         RON
                                                                                RON
           03 F064.                                                             RON
              04  FILLER        PICTURE X(4).                                   RON
              04  F06401        PICTURE X.                                      RON
           03 F065              PICTURE X.                                      RON
                                                                                RON
                                                                                RON
          02  MISC.                                                             RON
                                                                                RON
           03 F066              PICTURE X.                                      RON
           03 F067              PICTURE X.                                      RON
           03 FILLER            PICTURE X.                                      RON
                                                                                RON
                                                                                RON
          02  PILOT-DATA.                                                       RON
                                                                                RON
           03 F068.                                                             RON
              04  F06801        PICTURE X.                                      RON
              04  F06802        PICTURE X.                                      RON
           03 F069.                                                             RON
              04  F06901.                                                       RON
                  05  F0690101.                                                 RON
                      06  FILLER        PICTURE X(4).                           RON
                      06  F069010101    PICTURE X.                              RON
                  05  FILLER            PICTURE X.                              RON
              04  F06902.                                                       RON
                  05  F0690201.                                                 RON
                      06  FILLER        PICTURE X(4).                           RON
                      06  F069020101    PICTURE X.                              RON
                  05  FILLER            PICTURE X.                              RON
           03 F070.                                                             RON
              04  F07001.                                                       RON
                  05  F0700101.                                                 RON
                      06  FILLER        PICTURE X(4).                           RON
                      06  F070010101    PICTURE X.                              RON
                  05  FILLER            PICTURE X.                              RON
              04  F07002.                                                       RON
                  05  F0700201.                                                 RON
                      06  FILLER        PICTURE X(4).                           RON
                      06  F070020101    PICTURE X.                              RON
                  05  FILLER            PICTURE X.                              RON
           03 F071.                                                             RON
              04  F07101.                                                       RON
                  05  F0710101.                                                 RON
                      06  FILLER        PICTURE X.                              RON
                      06  F071010101    PICTURE X.                              RON
                  05  FILLER            PICTURE X.                              RON
              04  F07102.                                                       RON
                  05  F0710201.                                                 RON
                      06  FILLER        PICTURE X.                              RON
                      06  F071020101    PICTURE X.                              RON
                  05  FILLER            PICTURE X.                              RON
           03 F072.                                                             RON
              04  F07201.                                                       RON
                  05  F0720101    PICTURE X.                                    RON
                  05  FILLER      PICTURE X.                                    RON
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            04  F07202.
                05  F0720201     PICTURE X.
                05  FILLER       PICTURE X.
        03 F073.
            04  F07301.
                05  F0730101     PICTURE X.
                05  FILLER       PICTURE X.
            04  F07302.
                05  F0730201     PICTURE X.
                05  FILLER       PICTURE X.
        03 F074.
            04  F07401.
                05  F0740101     PICTURE X.
                05  FILLER       PICTURE X.
            04  F07402.
                05  F0740201     PICTURE X.
                05  FILLER       PICTURE X.
        03 F075.
            04  F07501.
                05  F0750101     PICTURE X.
                05  FILLER       PICTURE X.
            04  F07502.
                05  F0750201     PICTURE X.
                05  FILLER       PICTURE X.
        03 F076.
            04  F07601.
                05  F0760101     PICTURE X.
                05  FILLER       PICTURE X.
            04  F07602.
                05  F0760201     PICTURE X.
                05  FILLER       PICTURE X.
        03 F077                  PICTURE X.


      02  DUM1.

        03 FILLER           PICTURE X(20).


      02  CAUSE-FACTOR.

        03 F078     OCCURS 17 TIMES.
            04  F07801      PICTURE XX.
            04  F07802      PICTURE X.
            04  F07803.
                05  F0780301     PICTURE X.
                05  F0780302     PICTURE X.


      02  INJRY.

        03 F079             PICTURE X.
        03 F080A.
            04  F08001A OCCURS 3 TIMES.
                05  F0800101A   OCCURS 6 TIMES  PICTURE XXX.
            04  FILLER      PICTURE X(7).
        03 F080B    OCCURS 4 TIMES.
            04  F08001B     OCCURS 3 TIMES.
                05  F0800101B   OCCURS 6 TIMES  PICTURE XXX.
            04  FILLER      PICTURE X(8).
        03 F081.
            04  F08101  OCCURS 6 TIMES  PICTURE XXX.
            04  FILLER      PICTURE X(8).


      02  RMRKS.

        03 F082.
            04  F08201      PICTURE X.
            04  F08202      PICTURE X(49).
        03 FILLER           PICTURE X(11).

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       02  CAUSE.

        03 F083.
           04  F08301  OCCURS 50 TIMES PICTURE X.
        03 FILLER             PICTURE X(11).


       02  DUM2.

        03 FILLER             PICTURE X(20).


       02  E-P-DATA.

        03 F084               PICTURE X.
        03 F085               PICTURE X.
        03 F086               PICTURE X.
        03 F087               PICTURE X.
        03 F088               PICTURE X.
        03 F089               PICTURE X.


       02  OVERHAUL.

        03 F090.
           04  FILLER         PICTURE X(4).
           04  F09001         PICTURE X.
        03 F091.
           04  F09101  OCCURS 4 TIMES.
               05  FILLER        PICTURE XXX.
               05  F0910101      PICTURE X.
        03 F092.
           04  F09201  OCCURS 4 TIMES.
               05  FILLER        PICTURE XXX.
               05  F0920101      PICTURE X.
        03 F093.
           04  FILLER            PICTURE X(5).
           04  F09301            PICTURE X.
        03 F094.
           04  F09401            PICTURE X.
           04  FILLER            PICTURE X(11).
        03 FILLER                PICTURE X.


       02  WEATHER-SITE.

        03 F095                  PICTURE X.
        03 F096.
           04  FILLER            PICTURE X(4).
           04  F09601            PICTURE X.
        03 F097                  PICTURE X.
        03 F098.
           04  F09801            PICTURE X.
           04  F09802            PICTURE X.
        03 F099               PICTURE X.
        03 F100               PICTURE X.
        03 F101               PICTURE XX.
        03 F102               PICTURE X(4).
        03 F103.
           04  F10301         PICTURE X.
           04  F10302         PICTURE X.
           04  F10303         PICTURE X.
        03 F104               PICTURE XXX.
        03 F105               PICTURE XXX.
        03 F106.
           04  FILLER         PICTURE XX.
           04  F10601         PICTURE X.


       02  AAA.

        03 F107               PICTURE X.
        03 F108               PICTURE X.
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00365 C 003660         03 F109              PICTURE X.                                   RON
00366 C 003670         03 F110              PICTURE X.                                   RON
00367 C 003680         03 F111              PICTURE X.                                   RON
00368 C 003690         03 F112              PICTURE X.                                   RON
00369 C 003700         03 F113              PICTURE X.                                   RON
00370 C 003710         03 F114              PICTURE X.                                   RON
00371 C 003720         03 F115              PICTURE X.                                   RON
00372 C 003730         03 F116              PICTURE X.                                   RON
00373 C 003740         03 F117              PICTURE X.                                   RON
00374 C 003750         03 F118              PICTURE X.                                   RON
00375 C 003760         03 F119              PICTURE X.                                   RON
00376 C 003770                                                                           RON
00377 C 003780                                                                           RON
00378 C 003790        02  DUM3.                                                          RON
00379 C 003800                                                                           RON
00380 C 003810         03 FILLER            PICTURE X(20).                               RON
00381 C 003820                                                                           RON
00382 C 003830                                                                           RON
00383 C 003840        02  FLIGHT-DATA.                                                   RON
00384 C 003850                                                                           RON
00385 C 003860         03 F120.                                                          RON
00386 C 003870            04  FILLER        PICTURE XXX.                                 RON
00387 C 003880            04  F12001        PICTURE X.                                   RON
00388 C 003890         03 F121.                                                          RON
00389 C 003900            04  FILLER        PICTURE XXX.                                 RON
00390 C 003910            04  F12101        PICTURE X.                                   RON
00391 C 003920         03 F122              PICTURE XXX.                                 RON
00392 C 003930         03 F123              PICTURE XX.                                  RON
00393 C 003940         03 F124.                                                          RON
00394 C 003950            04  FILLER        PICTURE XXX.                                 RON
00395 C 003960            04  F12401        PICTURE X.                                   RON
00396 C 003970         03 F125.                                                          RON
00397 C 003980            04  F12501.                                                    RON
00398 C 003990                05  FILLER        PICTURE X.                               RON
00399 C 004000                05  F1250101      PICTURE X.                               RON
00400 C 004010            04  F12502.                                                    RON
00401 C 004020                05  FILLER        PICTURE XX.                              RON
00402 C 004030                05  F1250201      PICTURE X.                               RON
00403 C 004040            04  F12503.                                                    RON
00404 C 004050                05  FILLER        PICTURE XX.                              RON
00405 C 004060                05  F1250301      PICTURE X.                               RON
00406 C 004070         03 F126.                                                          RON
00407 C 004080            04  FILLER            PICTURE X.                               RON
00408 C 004090            04  F12601            PICTURE X.                               RON
00409 C 004100         03 F127.                                                          RON
00410 C 004110            04  FILLER            PICTURE X.                               RON
00411 C 004120            04  F12701            PICTURE X.                               RON
00412 C 004130         03 F128                  PICTURE XX.                              RON
00413 C 004140         03 F129.                                                          RON
00414 C 004150            04  FILLER            PICTURE X(16).                           RON
00415 C 004160            04  F12901            PICTURE X.                               RON
00416 C 004170         03 F130.                                                          RON
00417 C 004180            04  FILLER            PICTURE X(9).                            RON
00418 C 004190            04  F13001            PICTURE X.                               RON
00419 C 004200         03 FILLER                PICTURE X(4).                            RON
00420 C 004210                                                                           RON
00421 C 004220                                                                           RON
00422 C 004230        02  HUMAN-FACTORS.                                                 RON
00423 C 004240                                                                           RON
00424 C 004250         03 F131.                                                          RON
00425 C 004260            04  F13101            PICTURE X.                               RON
00426 C 004270            04  F13102            PICTURE X.                               RON
00427 C 004280            04  F13103            PICTURE X.                               RON
00428 C 004290            04  F13104            PICTURE X.                               RON
00429 C 004300         03 F132                  PICTURE XX.                              RON
00430 C 004310         03 F133.                                                          RON
00431 C 004320            04  F13301            PICTURE X.                               RON
00432 C 004330            04  F13302.                                                    RON
00433 C 004340                05  FILLER        PICTURE X.                               RON
00434 C 004350                05  F1330201      PICTURE X.                               RON
00435 C 004360         03 F134                  PICTURE X.                               RON
00436 C 004370         03 F135                  PICTURE X.                               RON
00437 C 004380         03 F136.                                                          RON
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C 004390          04  FILLER          PICTURE XXX.          RON
C 004400          04  F13601          PICTURE X.            RON
C 004410       03 F137.                                     RON
C 004420          04  F13701          PICTURE X.            RON
C 004430          04  F13702          PICTURE X.            RON
C 004440          04  F13703          PICTURE X.            RON
C 004450          04  F13704          PICTURE X.            RON
C 004460          04  F13705          PICTURE X.            RON
C 004470       03 F138                PICTURE X.            RON
C 004480       03 F139.                                     RON
C 004490          04  FILLER          PICTURE XX.           RON
C 004500          04  F13901          PICTURE X.            RON
C 004510       03 F140.                                     RON
C 004520          04  FILLER          PICTURE XX.           RON
C 004530          04  F14001          PICTURE X.            RON
C 004540       03 F141.                                     RON
C 004550          04  FILLER          PICTURE XX.           RON
C 004560          04  F14101          PICTURE X.            RON
C 004570       03 F142                PICTURE X.            RON
C 004580       03 F143                PICTURE X.            RON
C 004590       03 F144                PICTURE X.            RON
C 004600       03 F145                PICTURE X.            RON
C 004610       03 F146                PICTURE X.            RON
C 004620       03 F147                PICTURE X.            RON
C 004630       03 F148.                                     RON
C 004640          04  F14801          PICTURE X.            RON
C 004650          04  F14802          PICTURE X.            RON
C 004660          04  F14803          PICTURE X.            RON
C 004670          04  F14804          PICTURE X.            RON
C 004680       03 F149.                                     RON
C 004690          04  F14901.                               RON
C 004700              05  FILLER      PICTURE XX.           RON
C 004710              05  F1490101    PICTURE X.            RON
C 004720          04  F14902.                               RON
C 004730              05  FILLER      PICTURE XX.           RON
C 004740              05  F1490201    PICTURE X.            RON
C 004750       03 F150                PICTURE X.            RON
C 004760       03 F151.                                     RON
C 004770          04  F15101          PICTURE X.            RON
C 004780          04  F15102          PICTURE X.            RON
C 004790          04  F15103          PICTURE X.            RON
C 004800       03 F152.                                     RON
C 004810          04  FILLER          PICTURE XX.           RON
C 004820          04  F15201          PICTURE X.            RON
C 004830       03 F153                PICTURE X.            RON
C 004840       03 FILLER              PICTURE X(7).         RON
C 004850                                                    RON
C 004860                                                    RON
C 004870    02 FIRE-INFO.                                   RON
C 004880                                                    RON
C 004890       03 F154                PICTURE X.            RON
C 004900       03 F155                PICTURE X.            RON
C 004910       03 F156                PICTURE X.            RON
C 004920       03 F157                PICTURE X.            RON
C 004930       03 F158.                                     RON
C 004940          04  F15801          PICTURE X.            RON
C 004950          04  F15802.                               RON
C 004960              05  F1580201    PICTURE X.            RON
C 004970              05  F1580202    PICTURE X.            RON
C 004980          04  F15803.                               RON
C 004990              05  F1580301    PICTURE X.            RON
C 005000              05  F1580302    PICTURE X.            RON
C 005010       03 F159                PICTURE X.            RON
C 005020       03 F160                PICTURE X.            RON
C 005030       03 F161.                                     RON
C 005040          04  F16101          PICTURE X.            RON
C 005050          04  F16102          PICTURE X.            RON
C 005060                                                    RON
C 005070                                                    RON
C 005080    02 EQUIP.                                       RON
C 005090                                                    RON
C 005100       03 F162                PICTURE X.            RON
C 005110       03 F163                PICTURE X.            RON
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00511 C 005120       03 F164.                                           RON
00512 C 005130          04  F16401            PICTURE X.                RON
00513 C 005140          04  F16402            PICTURE X.                RON
00514 C 005150       03 F165                  PICTURE X.                RON
00515 C 005160       03 F166                  PICTURE X.                RON
00516 C 005170                                                          RON
00517 C 005180                                                          RON
00518 C 005190      02 W-B-DAMAGE.                                      RON
00519 C 005200                                                          RON
00520 C 005210       03 F167                  PICTURE X.                RON
00521 C 005220       03 F168                  PICTURE X.                RON
00522 C 005230       03 F169                  PICTURE X.                RON
00523 C 005240       03 F170                  PICTURE X.                RON
00524 C 005250       03 F171                  PICTURE X.                RON
00525 C 005260       03 F172                  PICTURE X.                RON
00526 C 005270       03 F173                  PICTURE X.                RON
00527 C 005280       03 F174.                                           RON
00528 C 005290          04  F17401            PICTURE X.                RON
00529 C 005300          04  F17402            PICTURE X.                RON
00530 C 005310       03 F175                  PICTURE X.                RON
00531 C 005320       03 F176                  PICTURE X.                RON
00532 C 005330       03 F177.                                           RON
00533 C 005340          04  F17701            PICTURE X.                RON
00534 C 005350          04  F17702            PICTURE X.                RON
00535 C 005360       03 F178                  PICTURE X.                RON
00536 C 005370       03 F179                  PICTURE X.                RON
00537 C 005380       03 F180                  PICTURE X.                RON
00538 C 005390       03 F181                  PICTURE X.                RON
00539 C 005400       03 F182                  PICTURE X.                RON
00540 C 005410       03 F183                  PICTURE X.                RON
00541 C 005420                                                          RON
00542 C 005430                                                          RON
00543 C 005440      02  DUM4.                                           RON
00544 C 005450                                                          RON
00545 C 005460       03 FILLER                PICTURE X(23).            RON
00546 C 005470       03 FILLER                PICTURE X(20).            RON
00547 C 005480                                                          RON
00548 C 005490                                                          RON
00549 C 005500      02  ADMIN-DATA.                                     RON
00550 C 005510                                                          RON
00551 C 005520       03 FILLER                PICTURE XXX.              RON
00552 C 005530       03 F184                  PICTURE X(12).            RON
00553 C 005540       03 F185                  PICTURE X(6).             RON
00554 C 005550       03 F186     OCCURS 3 TIMES.                        RON
00555 C 005560          04  F18601            PICTURE 99.               RON
00556 C 005570          04  F18602            PICTURE XX.               RON
00557 C 005580          04  F18603            PICTURE XX.               RON
00558 C 005590       03 F187                  PICTURE 99.               RON
00559 C 005600       03 F188                  PICTURE XXX.              RON
00560 C 005610       03 F189                  PICTURE X(13).            RON
00561 C 005620                                                          RON
00562 C 005630                                                          RON
00563 C 005640      02  IDN.                                            RON
00564 C 005650                                                          RON
00565 C 005660       03 F190                  PICTURE X(4).             RON
00566 C 005670                                                          RON
00567 C 005680                                                          RON
00568 C 005690      02  DUM5.                                           RON
00569 C 005700                                                          RON
00570 C 005710       03 FILLER                PICTURE X(20).            RON
00571 C 005720                                                          RON
00572 C 005730                                                          RON
00573 C 005740      02  AERIAL-APP.                                     RON
00574 C 005750                                                          RON
00575 C 005760       03 F191.                                           RON
00576 C 005770          04  FILLER            PICTURE XXX.              RON
00577 C 005780          04  F19101            PICTURE X.                RON
00578 C 005790       03 F192                  PICTURE X.                RON
00579 C 005800       03 F193                  PICTURE X.                RON
00580 C 005810       03 F194                  PICTURE X.                RON
00581 C 005820       03 F195                  PICTURE X.                RON
00582 C 005830       03 F196                  PICTURE X.                RON
00583 C 005840       03 F197                  PICTURE X.                RON
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         03 F198                  PICTURE X.                RON
         03 F199                  PICTURE X.                RON
         03 F200                  PICTURE X.                RON
         03 F201                  PICTURE X.                RON
         03 F202                  PICTURE X.                RON
         03 F203                  PICTURE X.                RON
         03 F204                  PICTURE X.                RON
         03 F205                  PICTURE X.                RON
         03 F206                  PICTURE X.                RON
         03 F207                  PICTURE X.                RON
         03 F208                  PICTURE X(5).             RON
         03 F209.                                           RON
            04  F20901            PICTURE X.                RON
            04  F20902            PICTURE X.                RON
            04  F20903            PICTURE X.                RON
         03 F210.                                           RON
            04  F21001            PICTURE X.                RON
            04  F21002            PICTURE X.                RON
            04  F21003            PICTURE X.                RON
         03 F211                  PICTURE X.                RON
         03 F212                  PICTURE X.                RON
                                                            RON
                                                            RON
       02  DUM6.                                            RON
                                                            RON
         03 FILLER                PICTURE X(28).            RON
         03 FILLER                PICTURE X(20).            RON
                                                            RON
                                                            RON
       02  COL.                                             RON
                                                            RON
         03 F213                  PICTURE X.                RON
         03 F214                  PICTURE X.                RON
         03 F215                  PICTURE X.                RON
         03 F216                  PICTURE X.                RON
         03 F217                  PICTURE X.                RON
         03 F218                  PICTURE X.                RON
         03 F219                  PICTURE X.                RON
         03 F220                  PICTURE XXX.              RON
         03 F221                  PICTURE XXX.              RON
         03 F222.                                           RON
            04  F22201            PICTURE XXX.              RON
            04  F22202            PICTURE XXX.              RON
         03 F223                  PICTURE X.                RON
         03 F224                  PICTURE X.                RON
         03 F225                  PICTURE X.                RON
         03 F226                  PICTURE X.                RON
         03 F227                  PICTURE X.                RON
                                                            RON
                                                            RON
       02  DUM7.                                            RON
                                                            RON
         03 FILLER                PICTURE X(37).            RON
                                                            RON
                                                            RON
       02  DITCH-SURVIVAL.                                  RON
                                                            RON
         03 F228                  PICTURE X.                RON
         03 F229                  PICTURE XX.               RON
         03 F230.                                           RON
            04  F23001            PICTURE XX.               RON
            04  F23002            PICTURE XXX.              RON
         03 F231                  PICTURE X.                RON
         03 F232                  PICTURE X.                RON
         03 FILLER                PICTURE X.                RON
         03 F233                  PICTURE X.                RON
         03 F234                  PICTURE X.                RON
         03 F235                  PICTURE X.                RON
         03 F236                  PICTURE X.                RON
         03 F237                  PICTURE X.                RON
         03 F238                  PICTURE X.                RON
         03 F239                  PICTURE X.                RON
       02  DUM8.                                            RON
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        03 FILLER                     PICTURE X(127).                RON
    FD  NTSB-TAPE
        RECORDING MODE IS F
        LABEL RECORDS ARE OMITTED
        DATA RECORD IS NTSB-OUT.
    01  NTSB-OUT            PIC X(1600).
    WORKING-STORAGE SECTION.
    77  HISAVE      PIC 9(3) VALUE 455.
    77  HI       PIC 9(3).
    77  LO          PIC 9(3) VALUE ZERO.
    77  I           PIC 9(3).
    77  SEARCH-WORD PIC X(11).
    77  FOUND-WORD  PIC X VALUE ZERO.
    77  REPLY-77          PIC X(4).
    01  NTSB-WORK-01.
        02  NTSB-WORK    PIC X(1600).
    01  FIELD-01.
        02  FIELD-1 PIC X(3).
        02  FIELD-3      PIC XX.
        02  FIELD-2 PIC X(6).
    01  MK-MOD-01.
        02  MK-MOD-02.
            03  FILLER  PIC X(11) VALUE  '00201100   '.
            03  FILLER  PIC X(11) VALUE  '00201500   '.
            03  FILLER  PIC X(11) VALUE  '00201500-A '.
            03  FILLER  PIC X(11) VALUE  '00201500-B '.
            03  FILLER  PIC X(11) VALUE  '00201500-S '.
            03  FILLER  PIC X(11) VALUE  '00201500B  '.
            03  FILLER  PIC X(11) VALUE  '00201500S  '.
            03  FILLER  PIC X(11) VALUE  '00201560   '.
            03  FILLER  PIC X(11) VALUE  '00201560-A '.
            03  FILLER  PIC X(11) VALUE  '00201560-E '.
            03  FILLER  PIC X(11) VALUE  '00201560A  '.
            03  FILLER  PIC X(11) VALUE  '00201560E  '.
            03  FILLER  PIC X(11) VALUE  '00202560-F '.
            03  FILLER  PIC X(11) VALUE  '00202560F  '.
            03  FILLER  PIC X(11) VALUE  '00202680   '.
            03  FILLER  PIC X(11) VALUE  '00202680-E '.
            03  FILLER  PIC X(11) VALUE  '00202680-F '.
            03  FILLER  PIC X(11) VALUE  '00202680-FL'.
            03  FILLER  PIC X(11) VALUE  '00202680-V '.
            03  FILLER  PIC X(11) VALUE  '00202680E  '.
            03  FILLER  PIC X(11) VALUE  '00202680F  '.
            03  FILLER  PIC X(11) VALUE  '00202680FL '.
            03  FILLER  PIC X(11) VALUE  '00202680FLP'.
            03  FILLER  PIC X(11) VALUE  '00202680FP '.
            03  FILLER  PIC X(11) VALUE  '00202680S  '.
            03  FILLER  PIC X(11) VALUE  '00202680T  '.
            03  FILLER  PIC X(11) VALUE  '00202680V  '.
            03  FILLER  PIC X(11) VALUE  '00202680W  '.
            03  FILLER  PIC X(11) VALUE  '00202681   '.
            03  FILLER  PIC X(11) VALUE  '00202690   '.
            03  FILLER  PIC X(11) VALUE  '00202690A  '.
            03  FILLER  PIC X(11) VALUE  '00205112   '.
            03  FILLER  PIC X(11) VALUE  '00312 7ECA '.
            03  FILLER  PIC X(11) VALUE  '003125-7CCM'.
            03  FILLER  PIC X(11) VALUE  '0031257BCM '.
            03  FILLER  PIC X(11) VALUE  '0031257CC  '.
            03  FILLER  PIC X(11) VALUE  '003127AC   '.
            03  FILLER  PIC X(11) VALUE  '003127ACA  '.
            03  FILLER  PIC X(11) VALUE  '003127ACM  '.
            03  FILLER  PIC X(11) VALUE  '003127BC   '.
            03  FILLER  PIC X(11) VALUE  '003127BCM  '.
            03  FILLER  PIC X(11) VALUE  '003127CCM  '.
            03  FILLER  PIC X(11) VALUE  '003127CGAA '.
            03  FILLER  PIC X(11) VALUE  '003127DC   '.
            03  FILLER  PIC X(11) VALUE  '003127EAC  '.
            03  FILLER  PIC X(11) VALUE  '003127EC   '.
            03  FILLER  PIC X(11) VALUE  '003127ECA  '.
            03  FILLER  PIC X(11) VALUE  '003127FC   '.
            03  FILLER  PIC X(11) VALUE  '003127GC   '.
            03  FILLER  PIC X(11) VALUE  '003127GC-AA'.
            03  FILLER  PIC X(11) VALUE  '003127GCA  '.
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009800   03 FILLER PIC X(11) VALUE '003127GCAA '.
009900   03 FILLER PIC X(11) VALUE '003127GCB  '.
010000   03 FILLER PIC X(11) VALUE '003127GCBA '.
010100   03 FILLER PIC X(11) VALUE '003127GCBC '.
010200   03 FILLER PIC X(11) VALUE '003127HC   '.
010300   03 FILLER PIC X(11) VALUE '003127KC-AB'.
010400   03 FILLER PIC X(11) VALUE '003127KCAB '.
010500   03 FILLER PIC X(11) VALUE '003198KCAB '.
010600   03 FILLER PIC X(11) VALUE '02217C-18S '.
010700   03 FILLER PIC X(11) VALUE '02217C18S  '.
010800   03 FILLER PIC X(11) VALUE '02217D-18-S'.
010900   03 FILLER PIC X(11) VALUE '02217D-18S '.
011000   03 FILLER PIC X(11) VALUE '02217D18   '.
011100   03 FILLER PIC X(11) VALUE '02217D18C  '.
011200   03 FILLER PIC X(11) VALUE '02217D18S  '.
011300   03 FILLER PIC X(11) VALUE '02217D185  '.
011400   03 FILLER PIC X(11) VALUE '02217E18   '.
011500   03 FILLER PIC X(11) VALUE '02217E18E  '.
011600   03 FILLER PIC X(11) VALUE '02217E18S  '.
011700   03 FILLER PIC X(11) VALUE '02217G-18-S'.
011800   03 FILLER PIC X(11) VALUE '02217G18S  '.
011900   03 FILLER PIC X(11) VALUE '02217H18   '.
012000   03 FILLER PIC X(11) VALUE '02217H18S  '.
012100   03 FILLER PIC X(11) VALUE '0221718    '.
012200   03 FILLER PIC X(11) VALUE '02220A-36  '.
012300   03 FILLER PIC X(11) VALUE '02220A33   '.
012400   03 FILLER PIC X(11) VALUE '02220A36   '.
012500   03 FILLER PIC X(11) VALUE '02220BE33  '.
012600   03 FILLER PIC X(11) VALUE '02220B35   '.
012700   03 FILLER PIC X(11) VALUE '02220C35   '.
012800   03 FILLER PIC X(11) VALUE '02220D35   '.
012900   03 FILLER PIC X(11) VALUE '02220E33   '.
013000   03 FILLER PIC X(11) VALUE '02220E33A  '.
013100   03 FILLER PIC X(11) VALUE '02220F33   '.
013200   03 FILLER PIC X(11) VALUE '02220F33A  '.
013300   03 FILLER PIC X(11) VALUE '02220G33   '.
013400   03 FILLER PIC X(11) VALUE '02220H-35  '.
013500   03 FILLER PIC X(11) VALUE '02220H35   '.
013600   03 FILLER PIC X(11) VALUE '02220J35   '.
013700   03 FILLER PIC X(11) VALUE '02220K35   '.
013800   03 FILLER PIC X(11) VALUE '02220M-35  '.
013900   03 FILLER PIC X(11) VALUE '02220M35   '.
014000   03 FILLER PIC X(11) VALUE '02220M35B  '.
014100   03 FILLER PIC X(11) VALUE '02220N35   '.
014200   03 FILLER PIC X(11) VALUE '02220P-35  '.
014300   03 FILLER PIC X(11) VALUE '02220P35   '.
014400   03 FILLER PIC X(11) VALUE '02220S-35  '.
014500   03 FILLER PIC X(11) VALUE '02220S35   '.
014600   03 FILLER PIC X(11) VALUE '02220V35   '.
014700   03 FILLER PIC X(11) VALUE '02220V35-TC'.
014800   03 FILLER PIC X(11) VALUE '02220V35A  '.
014900   03 FILLER PIC X(11) VALUE '02220V35ATC'.
015000   03 FILLER PIC X(11) VALUE '02220V35B  '.
015100   03 FILLER PIC X(11) VALUE '02220V35TC '.
015200   03 FILLER PIC X(11) VALUE '0222033    '.
015300   03 FILLER PIC X(11) VALUE '0222035    '.
015400   03 FILLER PIC X(11) VALUE '0222035-A33'.
015500   03 FILLER PIC X(11) VALUE '0222035-B33'.
015600   03 FILLER PIC X(11) VALUE '0222035-C33'.
015700   03 FILLER PIC X(11) VALUE '0222035-E33'.
015800   03 FILLER PIC X(11) VALUE '0222035-G33'.
015900   03 FILLER PIC X(11) VALUE '0222035-33 '.
016000   03 FILLER PIC X(11) VALUE '0222035B33 '.
016100   03 FILLER PIC X(11) VALUE '0222035C33A'.
016200   03 FILLER PIC X(11) VALUE '0222035S   '.
016300   03 FILLER PIC X(11) VALUE '0222036    '.
016400   03 FILLER PIC X(11) VALUE '02222A55   '.
016500   03 FILLER PIC X(11) VALUE '02223A65   '.
016600   03 FILLER PIC X(11) VALUE '02223A65-88'.
016700   03 FILLER PIC X(11) VALUE '02223A90   '.
016800   03 FILLER PIC X(11) VALUE '02223BE65  '.
016900   03 FILLER PIC X(11) VALUE '02223B80   '.
017000   03 FILLER PIC X(11) VALUE '02223B90   '.
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017100   03 FILLER PIC X(11) VALUE '02223C90   '.
017200   03 FILLER PIC X(11) VALUE '02223E90   '.
017300   03 FILLER PIC X(11) VALUE '0222365    '.
017400   03 FILLER PIC X(11) VALUE '0222365-A80'.
017500   03 FILLER PIC X(11) VALUE '0222365-A90'.
017600   03 FILLER PIC X(11) VALUE '0222365-880'.
017700   03 FILLER PIC X(11) VALUE '0222365-80 '.
017800   03 FILLER PIC X(11) VALUE '0222365-88 '.
017900   03 FILLER PIC X(11) VALUE '0222365A90 '.
018000   03 FILLER PIC X(11) VALUE '0222365S   '.
018100   03 FILLER PIC X(11) VALUE '0222370    '.
018200   03 FILLER PIC X(11) VALUE '0222390    '.
018300   03 FILLER PIC X(11) VALUE '02224B55   '.
018400   03 FILLER PIC X(11) VALUE '02224B55-95'.
018500   03 FILLER PIC X(11) VALUE '02224C55   '.
018600   03 FILLER PIC X(11) VALUE '02224D55   '.
018700   03 FILLER PIC X(11) VALUE '02224E55   '.
018800   03 FILLER PIC X(11) VALUE '02224E58   '.
018900   03 FILLER PIC X(11) VALUE '0222455    '.
019000   03 FILLER PIC X(11) VALUE '0222456T   '.
019100   03 FILLER PIC X(11) VALUE '0222456TC  '.
019200   03 FILLER PIC X(11) VALUE '0222458    '.
019300   03 FILLER PIC X(11) VALUE '02225A-23  '.
019400   03 FILLER PIC X(11) VALUE '02225A-23A '.
019500   03 FILLER PIC X(11) VALUE '02225A19   '.
019600   03 FILLER PIC X(11) VALUE '02225A23   '.
019700   03 FILLER PIC X(11) VALUE '02225A23-19'.
019800   03 FILLER PIC X(11) VALUE '02225A23-24'.
019900   03 FILLER PIC X(11) VALUE '02225A23A  '.
020000   03 FILLER PIC X(11) VALUE '02225A24R  '.
020100   03 FILLER PIC X(11) VALUE '02225B-23  '.
020200   03 FILLER PIC X(11) VALUE '02225BE-23 '.
020300   03 FILLER PIC X(11) VALUE '02225BE23  '.
020400   03 FILLER PIC X(11) VALUE '02225B19   '.
020500   03 FILLER PIC X(11) VALUE '02225B23   '.
020600   03 FILLER PIC X(11) VALUE '02225B23-19'.
020700   03 FILLER PIC X(11) VALUE '02225C-23  '.
020800   03 FILLER PIC X(11) VALUE '02225C23   '.
020900   03 FILLER PIC X(11) VALUE '02225M-23  '.
021000   03 FILLER PIC X(11) VALUE '0222519    '.
021100   03 FILLER PIC X(11) VALUE '0222519A   '.
021200   03 FILLER PIC X(11) VALUE '0222523    '.
021300   03 FILLER PIC X(11) VALUE '0222523-19 '.
021400   03 FILLER PIC X(11) VALUE '0222523-19A'.
021500   03 FILLER PIC X(11) VALUE '02226A60   '.
021600   03 FILLER PIC X(11) VALUE '0222660    '.
021700   03 FILLER PIC X(11) VALUE '02227A99A  '.
021800   03 FILLER PIC X(11) VALUE '02227B99   '.
021900   03 FILLER PIC X(11) VALUE '02227100   '.
022000   03 FILLER PIC X(11) VALUE '0222799    '.
022100   03 FILLER PIC X(11) VALUE '0222799A   '.
022200   03 FILLER PIC X(11) VALUE '034058-1   '.
022300   03 FILLER PIC X(11) VALUE '034058-1A  '.
022400   03 FILLER PIC X(11) VALUE '03912 150  '.
022500   03 FILLER PIC X(11) VALUE '03912A150  '.
022600   03 FILLER PIC X(11) VALUE '03912A150-K'.
022700   03 FILLER PIC X(11) VALUE '03912A150K '.
022800   03 FILLER PIC X(11) VALUE '03912A150K '.
022900   03 FILLER PIC X(11) VALUE '03912A150L '.
023000   03 FILLER PIC X(11) VALUE '03912150F  '.
023100   03 FILLER PIC X(11) VALUE '03912150K  '.
023200   03 FILLER PIC X(11) VALUE '03912150   '.
023300   03 FILLER PIC X(11) VALUE '03912150A  '.
023400   03 FILLER PIC X(11) VALUE '03912150B  '.
023500   03 FILLER PIC X(11) VALUE '03912150C  '.
023600   03 FILLER PIC X(11) VALUE '03912150C  '.
023700   03 FILLER PIC X(11) VALUE '03912150E  '.
023800   03 FILLER PIC X(11) VALUE '03912150F  '.
023900   03 FILLER PIC X(11) VALUE '03912150G  '.
024000   03 FILLER PIC X(11) VALUE '03912150H  '.
024100   03 FILLER PIC X(11) VALUE '03912150J  '.
024200   03 FILLER PIC X(11) VALUE '03912150K  '.
024300   03 FILLER PIC X(11) VALUE '03912150L  '.
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024400      03  FILLER  PIC  X(11)  VALUE  '03914172   '.
024500      03  FILLER  PIC  X(11)  VALUE  '03914172A  '.
024600      03  FILLER  PIC  X(11)  VALUE  '03914172B  '.
024700      03  FILLER  PIC  X(11)  VALUE  '03914172C  '.
024800      03  FILLER  PIC  X(11)  VALUE  '03914172D  '.
024900      03  FILLER  PIC  X(11)  VALUE  '03914172E  '.
025000      03  FILLER  PIC  X(11)  VALUE  '03914172F  '.
025100      03  FILLER  PIC  X(11)  VALUE  '03914172G  '.
025200      03  FILLER  PIC  X(11)  VALUE  '03914172H  '.
025300      03  FILLER  PIC  X(11)  VALUE  '03914172I  '.
025400      03  FILLER  PIC  X(11)  VALUE  '03914172K  '.
025500      03  FILLER  PIC  X(11)  VALUE  '03914172L  '.
025600      03  FILLER  PIC  X(11)  VALUE  '03914172M  '.
025700      03  FILLER  PIC  X(11)  VALUE  '03914172S  '.
025800      03  FILLER  PIC  X(11)  VALUE  '03914177   '.
025900      03  FILLER  PIC  X(11)  VALUE  '03916150   '.
026000      03  FILLER  PIC  X(11)  VALUE  '03916180   '.
026100      03  FILLER  PIC  X(11)  VALUE  '03916180A  '.
026200      03  FILLER  PIC  X(11)  VALUE  '03916180B  '.
026300      03  FILLER  PIC  X(11)  VALUE  '03916180C  '.
026400      03  FILLER  PIC  X(11)  VALUE  '03916180D  '.
026500      03  FILLER  PIC  X(11)  VALUE  '03916180E  '.
026600      03  FILLER  PIC  X(11)  VALUE  '03916180F  '.
026700      03  FILLER  PIC  X(11)  VALUE  '03916180G  '.
026800      03  FILLER  PIC  X(11)  VALUE  '03916180H  '.
026900      03  FILLER  PIC  X(11)  VALUE  '03916180J  '.
027000      03  FILLER  PIC  X(11)  VALUE  '03916182   '.
027100      03  FILLER  PIC  X(11)  VALUE  '03916182L  '.
027200      03  FILLER  PIC  X(11)  VALUE  '03917180   '.
027300      03  FILLER  PIC  X(11)  VALUE  '03917182   '.
027400      03  FILLER  PIC  X(11)  VALUE  '03917182-E '.
027500      03  FILLER  PIC  X(11)  VALUE  '03917182A  '.
027600      03  FILLER  PIC  X(11)  VALUE  '03917182B  '.
027700      03  FILLER  PIC  X(11)  VALUE  '03917182C  '.
027800      03  FILLER  PIC  X(11)  VALUE  '03917182D  '.
027900      03  FILLER  PIC  X(11)  VALUE  '03917182E  '.
028000      03  FILLER  PIC  X(11)  VALUE  '03917182F  '.
028100      03  FILLER  PIC  X(11)  VALUE  '03917182G  '.
028200      03  FILLER  PIC  X(11)  VALUE  '03917182H  '.
028300      03  FILLER  PIC  X(11)  VALUE  '03917182J  '.
028400      03  FILLER  PIC  X(11)  VALUE  '03917182K  '.
028500      03  FILLER  PIC  X(11)  VALUE  '03917182L  '.
028600      03  FILLER  PIC  X(11)  VALUE  '03917182M  '.
028700      03  FILLER  PIC  X(11)  VALUE  '03917182N  '.
028800      03  FILLER  PIC  X(11)  VALUE  '03917182P  '.
028900      03  FILLER  PIC  X(11)  VALUE  '03917182R  '.
029000      03  FILLER  PIC  X(11)  VALUE  '03917182S  '.
029100      03  FILLER  PIC  X(11)  VALUE  '03917185   '.
029200      03  FILLER  PIC  X(11)  VALUE  '03919T-210 '.
029300      03  FILLER  PIC  X(11)  VALUE  '03919T210  '.
029400      03  FILLER  PIC  X(11)  VALUE  '03919T210-H'.
029500      03  FILLER  PIC  X(11)  VALUE  '03919T210F '.
029600      03  FILLER  PIC  X(11)  VALUE  '03919T210G '.
029700      03  FILLER  PIC  X(11)  VALUE  '03919T210H '.
029800      03  FILLER  PIC  X(11)  VALUE  '03919T210J '.
029900      03  FILLER  PIC  X(11)  VALUE  '03919T210K '.
030000      03  FILLER  PIC  X(11)  VALUE  '03919T210L '.
030100      03  FILLER  PIC  X(11)  VALUE  '03919210   '.
030200      03  FILLER  PIC  X(11)  VALUE  '03919210-5 '.
030300      03  FILLER  PIC  X(11)  VALUE  '03919210A  '.
030400      03  FILLER  PIC  X(11)  VALUE  '03919210B  '.
030500      03  FILLER  PIC  X(11)  VALUE  '03919210C  '.
030600      03  FILLER  PIC  X(11)  VALUE  '03919210D  '.
030700      03  FILLER  PIC  X(11)  VALUE  '03919210E  '.
030800      03  FILLER  PIC  X(11)  VALUE  '03919210F  '.
030900      03  FILLER  PIC  X(11)  VALUE  '03919210G  '.
031000      03  FILLER  PIC  X(11)  VALUE  '03919210H  '.
031100      03  FILLER  PIC  X(11)  VALUE  '03919210J  '.
031200      03  FILLER  PIC  X(11)  VALUE  '03919210K  '.
031300      03  FILLER  PIC  X(11)  VALUE  '03919210L  '.
031400      03  FILLER  PIC  X(11)  VALUE  '03919210T  '.
031500      03  FILLER  PIC  X(11)  VALUE  '03922T310P '.
031600      03  FILLER  PIC  X(11)  VALUE  '03922T310Q '.
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031700          03  FILLER  PIC  X(11)  VALUE  '03922310P  '.
031800          03  FILLER  PIC  X(11)  VALUE  '03922310   '.
031900          03  FILLER  PIC  X(11)  VALUE  '03922310A  '.
032000          03  FILLER  PIC  X(11)  VALUE  '03922310B  '.
032100          03  FILLER  PIC  X(11)  VALUE  '03922310C  '.
032200          03  FILLER  PIC  X(11)  VALUE  '03922310D  '.
032300          03  FILLER  PIC  X(11)  VALUE  '03922310E  '.
032400          03  FILLER  PIC  X(11)  VALUE  '03922310G  '.
032500          03  FILLER  PIC  X(11)  VALUE  '03922310H  '.
032600          03  FILLER  PIC  X(11)  VALUE  '03922310I  '.
032700          03  FILLER  PIC  X(11)  VALUE  '03922310J  '.
032800          03  FILLER  PIC  X(11)  VALUE  '03922310K  '.
032900          03  FILLER  PIC  X(11)  VALUE  '03922310L  '.
033000          03  FILLER  PIC  X(11)  VALUE  '03922310N  '.
033100          03  FILLER  PIC  X(11)  VALUE  '03922310P  '.
033200          03  FILLER  PIC  X(11)  VALUE  '03922310Q  '.
033300          03  FILLER  PIC  X(11)  VALUE  '03926A185E '.
033400          03  FILLER  PIC  X(11)  VALUE  '03926A185F '.
033500          03  FILLER  PIC  X(11)  VALUE  '03926185   '.
033600          03  FILLER  PIC  X(11)  VALUE  '03926185A  '.
033700          03  FILLER  PIC  X(11)  VALUE  '03926185B  '.
033800          03  FILLER  PIC  X(11)  VALUE  '03926185C  '.
033900          03  FILLER  PIC  X(11)  VALUE  '03926185D  '.
034000          03  FILLER  PIC  X(11)  VALUE  '03926185E  '.
034100          03  FILLER  PIC  X(11)  VALUE  '03926185F  '.
034200          03  FILLER  PIC  X(11)  VALUE  '03927340   '.
034300          03  FILLER  PIC  X(11)  VALUE  '03929P206  '.
034400          03  FILLER  PIC  X(11)  VALUE  '03929P206A '.
034500          03  FILLER  PIC  X(11)  VALUE  '03929P206B '.
034600          03  FILLER  PIC  X(11)  VALUE  '03929P206C '.
034700          03  FILLER  PIC  X(11)  VALUE  '03929TP206 '.
034800          03  FILLER  PIC  X(11)  VALUE  '03929TP206B'.
034900          03  FILLER  PIC  X(11)  VALUE  '03929TP206C'.
035000          03  FILLER  PIC  X(11)  VALUE  '03929TP206D'.
035100          03  FILLER  PIC  X(11)  VALUE  '03929TU206 '.
035200          03  FILLER  PIC  X(11)  VALUE  '03929TU206A'.
035300          03  FILLER  PIC  X(11)  VALUE  '03929TU206B'.
035400          03  FILLER  PIC  X(11)  VALUE  '03929TU206C'.
035500          03  FILLER  PIC  X(11)  VALUE  '03929TU206D'.
035600          03  FILLER  PIC  X(11)  VALUE  '03929TU206E'.
035700          03  FILLER  PIC  X(11)  VALUE  '03929TU206F'.
035800          03  FILLER  PIC  X(11)  VALUE  '03929TU206U'.
035900          03  FILLER  PIC  X(11)  VALUE  '03929U206  '.
036000          03  FILLER  PIC  X(11)  VALUE  '03929U206A '.
036100          03  FILLER  PIC  X(11)  VALUE  '03929U206B '.
036200          03  FILLER  PIC  X(11)  VALUE  '03929U206C '.
036300          03  FILLER  PIC  X(11)  VALUE  '03929U206D '.
036400          03  FILLER  PIC  X(11)  VALUE  '03929U206E '.
036500          03  FILLER  PIC  X(11)  VALUE  '03929U206F '.
036600          03  FILLER  PIC  X(11)  VALUE  '03929206   '.
036700          03  FILLER  PIC  X(11)  VALUE  '03929206A  '.
036800          03  FILLER  PIC  X(11)  VALUE  '03929206B  '.
036900          03  FILLER  PIC  X(11)  VALUE  '03929206D  '.
037000          03  FILLER  PIC  X(11)  VALUE  '03929206P  '.
037100          03  FILLER  PIC  X(11)  VALUE  '03930T-337 '.
037200          03  FILLER  PIC  X(11)  VALUE  '03930T-337C'.
037300          03  FILLER  PIC  X(11)  VALUE  '03930T337  '.
037400          03  FILLER  PIC  X(11)  VALUE  '03930T337C '.
037500          03  FILLER  PIC  X(11)  VALUE  '03930T337D '.
037600          03  FILLER  PIC  X(11)  VALUE  '03930T337E '.
037700          03  FILLER  PIC  X(11)  VALUE  '03930T337F '.
037800          03  FILLER  PIC  X(11)  VALUE  '03930337   '.
037900          03  FILLER  PIC  X(11)  VALUE  '03930337A  '.
038000          03  FILLER  PIC  X(11)  VALUE  '03930337B  '.
038100          03  FILLER  PIC  X(11)  VALUE  '03930337C  '.
038200          03  FILLER  PIC  X(11)  VALUE  '03930337D  '.
038300          03  FILLER  PIC  X(11)  VALUE  '03930337E  '.
038400          03  FILLER  PIC  X(11)  VALUE  '03930337F  '.
038500          03  FILLER  PIC  X(11)  VALUE  '03930337G  '.
038600          03  FILLER  PIC  X(11)  VALUE  '03931401   '.
038700          03  FILLER  PIC  X(11)  VALUE  '03931401A  '.
038800          03  FILLER  PIC  X(11)  VALUE  '03931401B  '.
038900          03  FILLER  PIC  X(11)  VALUE  '03931402   '.
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039000   03  FILLER  PIC  X(11)  VALUE  '039314028  '.
039100   03  FILLER  PIC  X(11)  VALUE  '03931411   '.
039200   03  FILLER  PIC  X(11)  VALUE  '03931411A  '.
039300   03  FILLER  PIC  X(11)  VALUE  '03931414   '.
039400   03  FILLER  PIC  X(11)  VALUE  '03932A-188 '.
039500   03  FILLER  PIC  X(11)  VALUE  '03932AG188 '.
039600   03  FILLER  PIC  X(11)  VALUE  '03932A188  '.
039700   03  FILLER  PIC  X(11)  VALUE  '03932A188A '.
039800   03  FILLER  PIC  X(11)  VALUE  '03932A188B '.
039900   03  FILLER  PIC  X(11)  VALUE  '03932188   '.
040000   03  FILLER  PIC  X(11)  VALUE  '03932188A  '.
040100   03  FILLER  PIC  X(11)  VALUE  '03932188B  '.
040200   03  FILLER  PIC  X(11)  VALUE  '03932188C  '.
040300   03  FILLER  PIC  X(11)  VALUE  '03933C177  '.
040400   03  FILLER  PIC  X(11)  VALUE  '03933177   '.
040500   03  FILLER  PIC  X(11)  VALUE  '03933177A  '.
040600   03  FILLER  PIC  X(11)  VALUE  '03933177B  '.
040700   03  FILLER  PIC  X(11)  VALUE  '03934421   '.
040800   03  FILLER  PIC  X(11)  VALUE  '03934421A  '.
040900   03  FILLER  PIC  X(11)  VALUE  '03934421B  '.
041000   03  FILLER  PIC  X(11)  VALUE  '03935T207  '.
041100   03  FILLER  PIC  X(11)  VALUE  '03935207   '.
041200   03  FILLER  PIC  X(11)  VALUE  '03936177 RG'.
041300   03  FILLER  PIC  X(11)  VALUE  '03936177RG '.
041400   03  FILLER  PIC  X(11)  VALUE  '0560114-19 '.
041500   03  FILLER  PIC  X(11)  VALUE  '0560114-192'.
041600   03  FILLER  PIC  X(11)  VALUE  '0560114-193'.
041700   03  FILLER  PIC  X(11)  VALUE  '056011419-2'.
041800   03  FILLER  PIC  X(11)  VALUE  '0560114193A'.
041900   03  FILLER  PIC  X(11)  VALUE  '05603A-1   '.
042000   03  FILLER  PIC  X(11)  VALUE  '05603AA-1  '.
042100   03  FILLER  PIC  X(11)  VALUE  '05603AA-1A '.
042200   03  FILLER  PIC  X(11)  VALUE  '05603AA-1B '.
042300   03  FILLER  PIC  X(11)  VALUE  '05603AA1   '.
042400   03  FILLER  PIC  X(11)  VALUE  '05603AA1-A '.
042500   03  FILLER  PIC  X(11)  VALUE  '05603AA1-B '.
042600   03  FILLER  PIC  X(11)  VALUE  '05603AA1-1A'.
042700   03  FILLER  PIC  X(11)  VALUE  '05603AA1A  '.
042800   03  FILLER  PIC  X(11)  VALUE  '05603AA1B  '.
042900   03  FILLER  PIC  X(11)  VALUE  '05605AA-5  '.
043000   03  FILLER  PIC  X(11)  VALUE  '05605AA5   '.
043100   03  FILLER  PIC  X(11)  VALUE  '07113G-164 '.
043200   03  FILLER  PIC  X(11)  VALUE  '07113G-164A'.
043300   03  FILLER  PIC  X(11)  VALUE  '07113G164  '.
043400   03  FILLER  PIC  X(11)  VALUE  '07113G164A '.
043500   03  FILLER  PIC  X(11)  VALUE  '07113G64A  '.
043600   03  FILLER  PIC  X(11)  VALUE  '07113164   '.
043700   03  FILLER  PIC  X(11)  VALUE  '07113164A  '.
043800   03  FILLER  PIC  X(11)  VALUE  '10103M-20  '.
043900   03  FILLER  PIC  X(11)  VALUE  '10103M-20C '.
044000   03  FILLER  PIC  X(11)  VALUE  '10103M-20C '.
044100   03  FILLER  PIC  X(11)  VALUE  '10103M-20F '.
044200   03  FILLER  PIC  X(11)  VALUE  '10103M-20G '.
044300   03  FILLER  PIC  X(11)  VALUE  '10103MK-20E'.
044400   03  FILLER  PIC  X(11)  VALUE  '10103M20-C '.
044500   03  FILLER  PIC  X(11)  VALUE  '10103M20-F '.
044600   03  FILLER  PIC  X(11)  VALUE  '10103M20B  '.
044700   03  FILLER  PIC  X(11)  VALUE  '10103M20C  '.
044800   03  FILLER  PIC  X(11)  VALUE  '10103M20D  '.
044900   03  FILLER  PIC  X(11)  VALUE  '10103M20E  '.
045000   03  FILLER  PIC  X(11)  VALUE  '10103M20F  '.
045100   03  FILLER  PIC  X(11)  VALUE  '10103M20G  '.
045200   03  FILLER  PIC  X(11)  VALUE  '10103M20H  '.
045300   03  FILLER  PIC  X(11)  VALUE  '10103M21   '.
045400   03  FILLER  PIC  X(11)  VALUE  '10103M21F  '.
045500   03  FILLER  PIC  X(11)  VALUE  '1010320F   '.
045600   03  FILLER  PIC  X(11)  VALUE  '10103201   '.
045700   03  FILLER  PIC  X(11)  VALUE  '10104M-22  '.
045800   03  FILLER  PIC  X(11)  VALUE  '10104M20F  '.
045900   03  FILLER  PIC  X(11)  VALUE  '10104M22   '.
046000   03  FILLER  PIC  X(11)  VALUE  '12420PA-18 '.
046100   03  FILLER  PIC  X(11)  VALUE  '12420PA-18A'.
046200   03  FILLER  PIC  X(11)  VALUE  '12420PA-18C'.
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                 03  FILLER   PIC  X(11)  VALUE   '12420PA-18S'.
                 03  FILLER   PIC  X(11)  VALUE   '12420PA18  '.
                 03  FILLER   PIC  X(11)  VALUE   '12424PA-23 '.
                 03  FILLER   PIC  X(11)  VALUE   '12424PA23  '.
                 03  FILLER   PIC  X(11)  VALUE   '12425PA-23 '.
                 03  FILLER   PIC  X(11)  VALUE   '12425PA-24 '.
                 03  FILLER   PIC  X(11)  VALUE   '12425PA24  '.
                 03  FILLER   PIC  X(11)  VALUE   '12426PA-25 '.
                 03  FILLER   PIC  X(11)  VALUE   '12426PA25  '.
                 03  FILLER   PIC  X(11)  VALUE   '12428PA-24 '.
                 03  FILLER   PIC  X(11)  VALUE   '12428PA-28 '.
                 03  FILLER   PIC  X(11)  VALUE   '12428PA-28R'.
                 03  FILLER   PIC  X(11)  VALUE   '12428PA-28S'.
                 03  FILLER   PIC  X(11)  VALUE   '12428PA28  '.
                 03  FILLER   PIC  X(11)  VALUE   '12428PA28-R'.
                 03  FILLER   PIC  X(11)  VALUE   '12429PA-30 '.
                 03  FILLER   PIC  X(11)  VALUE   '12429PA-30B'.
                 03  FILLER   PIC  X(11)  VALUE   '12429PA-32 '.
                 03  FILLER   PIC  X(11)  VALUE   '12429PA-39 '.
                 03  FILLER   PIC  X(11)  VALUE   '12429PA30  '.
                 03  FILLER   PIC  X(11)  VALUE   '12430PA-32 '.
                 03  FILLER   PIC  X(11)  VALUE   '12430PA32  '.
                 03  FILLER   PIC  X(11)  VALUE   '12431PA-31 '.
                 03  FILLER   PIC  X(11)  VALUE   '12431PA-31A'.
                 03  FILLER   PIC  X(11)  VALUE   '12431PA-31P'.
                 03  FILLER   PIC  X(11)  VALUE   '12432PA-34 '.
                 03  FILLER   PIC  X(11)  VALUE   '14803S-2D  '.
                 03  FILLER   PIC  X(11)  VALUE   '14803S-2R  '.
                 03  FILLER   PIC  X(11)  VALUE   '14803S2R   '.
                 03  FILLER   PIC  X(11)  VALUE   '14803THRUSH'.
                 03  FILLER   PIC  X(11)  VALUE   '1480360OS2D'.
                 03  FILLER   PIC  X(11)  VALUE   '1480360OS2R'.
                 03  FILLER   PIC  X(11)  VALUE   '1480360OS24'.
                 03  FILLER   PIC  X(11)  VALUE   '14803600S2R'.
                 03  FILLER   PIC  X(11)  VALUE   '21601MU-2  '.
                 03  FILLER   PIC  X(11)  VALUE   '21601MU-2B '.
                 03  FILLER   PIC  X(11)  VALUE   '21601MU-2F '.
                 03  FILLER   PIC  X(11)  VALUE   '21601MU-2G '.
                 03  FILLER   PIC  X(11)  VALUE   '21601MU2B20'.
            02   MK-MOD REDEFINES MK-MOD-02 OCCURS 550 TIMES PIC X(11).
       PROCEDURE DIVISION.
           OPEN INPUT NTSB  OUTPUT NTSB-TAPE.
       READ-NTSB.
           READ NTSB INTO NTSB-WORK-01 AT END GO TO END-OF-TAPE.
           MOVE F012 TO FIELD-1.
           MOVE F007 TO FIELD-2.
           MOVE F013 TO FIELD-3.
           MOVE FIELD-01 TO SEARCH-WORD.
           MOVE ZERO TO FOUND-WORD.
           PERFORM MAKE-MODEL THRU END-BI.
           IF FOUND-WORD = ZERO GO TO READ-NTSB.
           WRITE NTSB-OUT  FROM NTSB-REC.
           GO TO READ-NTSB.
       END-OF-TAPE.
           CLOSE NTSB.
               DISPLAY 'IF THIS IS THE LAST FILE ENTER LAST'
                   UPON CONSOLE
               DISPLAY 'IF NOT THEN MOUNT NEXT TAPE AND ENTER NEXT'
                   UPON CONSOLE
               ACCEPT REPLY-77 FROM CONSOLE.
       REPLY-TEST.
           IF REPLY-77 = SPACES OR 'NEXT' OR 'LAST' NEXT SENTENCE ELSE
               DISPLAY 'YOU GOOFED' UPON CONSOLE
               DISPLAY 'REENTER YOUR RESPONSE' UPON CONSOLE
               ACCEPT REPLY-77 FROM  CONSOLE
               GO TO REPLY-TEST.
           IF REPLY-77 = 'NEXT'
           OPEN INPUT NTSB
           GO TO READ-NTSB.
           IF REPLY-77 = 'LAST'
           CLOSE NTSB-TAPE WITH LOCK.
           STOP RUN.
       MAKE-MODEL.
```

```
     MOVE ZERO TO LO.
     MOVE HISAVE TO HI.
 AA.  COMPUTE I = (HI + LO) / 2.
     IF SEARCH-WORD LESS THAN MK-MOD (I)
         MOVE I TO HI
         GO TO BB.
     IF SEARCH-WORD GREATER THAN MK-MOD (I)
         MOVE I TO LO
         GO TO BB.
     MOVE '1' TO FOUND-WORD.
     GO TO END-BI.
 BB.  IF I LESS THAN (HI - LO) GO TO AA.
 END-BI.
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DOS AMERICAN NATIONAL STANDARD COBOL   VERSION 3 REL3.2 PP NO. 5736-CB2

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  [illegible]=YES,SXREF
  [illegible]D DIVISION
  [illegible] PROGRAM-ID. [illegible]TS80001.
  000300 AUTHOR. J. A. SUMNER.
  000400 INSTALLATION. THE CESSNA AIRCRAFT COMPANY.
  000500 DATE-WRITTEN. 9-20-75.
  000600 DATE-COMPILED. 04/09/76.
  000700 SECURITY. NOT CLASSIFIED.
  000800 REMARKS.
  000900      THIS PROGRAM SURVEYS CERTAIN NTSB (NATIONAL TRANSPORTATION &
  001000      SAFETY BOARD) FILES, 1971 - 1973, TO SATISFY THE REQUIREMENTS
  001100      OF A SUB-CONTRACT WITH LOCKHEED AIRCRAFT CO. IN THEIR EFFORT
  001200      TO PRODUCE A MATHEMATICAL MODEL OF AN AIRCRAFT CRASH.
  001300 ENVIRONMENT DIVISION.
  001400 CONFIGURATION SECTION.
  001500 SOURCE-COMPUTER.  IBM-370.
  001600 OBJECT-COMPUTER.  IBM-370.
  001700 INPUT-OUTPUT SECTION.
  001800 FILE-CONTROL.
  001900      SELECT NTSB ASSIGN SYS018-UT-2400-S.
  002000      SELECT HEAD ASSIGN SYS019-DA-3330-D
  002100          ACCESS IS RANDOM
  002200          ACTUAL KEY IS ACT-KEY.
  002300      SELECT PRT ASSIGN SYS016-UR-1403-S
  002400          RESERVE NO ALTERNATE AREA.
  002500 DATA DIVISION.
  002600 FILE SECTION.
  002700 FD   HEAD
  002800      LABEL RECORDS ARE STANDARD
  002900      DATA RECORD IS HEADERR.
  003000 01   HEADERR.
  003100      02  HDER              PIC X(68).
  003200 FD   PRT
  003300      LABEL RECORDS ARE OMITTED
  003400      DATA RECORD IS P-REC.
  003500 01   P-REC                 PIC X(133).
  003600 FD   NTSB
  003700      LABEL RECORDS ARE OMITTED
  003800      RECORDING MODE IS F
  003900      DATA RECORD IS NTSB-REC.
  004000 01   NTSB-REC COPY NTSBMSTR REPLACING REC BY NTSB-REC.
C 000270 01   NTSB-REC.                                                 RON
C 000280      02  F001.                                                 RON
C 000290          03  F00101        PICTURE 99.                         RON
C 000300          03  F00102        PICTURE XX.                         RON
C 000310          03  F00103        PICTURE XX.                         RON
C 000320      02  F002              PICTURE X(6).                       RON
C 000330      02  F003              PICTURE X(10).                      RON
C 000340      02  F004.                                                 RON
C 000350          03  FILLER        PICTURE X(5).                       RON
C 000360          03  F00401        PICTURE X.                          RON
C 000370      02  AF004   REDEFINES F004.                               RON
C 000380          03  AF00401       PICTURE 99.                         RON
C 000390          03  AF00402       PICTURE XX.                         RON
C 000400          03  AF00403       PICTURE XX.                         RON
C 000410      02  F005.                                                 RON
C 000420          03  F00501        PICTURE X.                          RON
C 000430          03  F00502.                                           RON
C 000440              04  FILLER      PICTURE X(16).                    RON
C 000450              04  F0050201    PICTURE X.                        RON
C 000460      02  F006              PICTURE X(11).                      RON
C 000470      02  F007              PICTURE X(6).                       RON
C 000480      02  F008.                                                 RON
C 000490          03  FILLER        PICTURE X(9).                       RON
C 000500          03  F00801        PICTURE X.                          RON
C 000510      02  F009.                                                 RON
C 000520          03  FILLER        PICTURE XXX.                        RON
C 000530          03  F00901        PICTURE X.                          RON
C 000540      02  FILLER            PICTURE X.                          RON
C 000550                                                                RON
C 000560                                                                RON
C 000570      02  GEN-INFO.                                             RON
C 000580                                                                RON
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C 000590      03 F010                PICTURE X.                            RON
C 000600      03 F011                PICTURE XX.                           RON
C 000610      03 F012                PICTURE XXX.                          RON
C 000620      03 F013                PICTURE XX.                           RON
C 000630      03 F014                PICTURE XX.                           RON
C 000640      03 F015                PICTURE XX.                           RON
C 000650      03 F016                PICTURE X.                            RON
C 000660      03 F017                PICTURE X.                            RON
C 000670      03 F018                PICTURE X.                            RON
C 000680      03 F019                PICTURE X.                            RON
C 000690      03 F020                PICTURE X.                            RON
C 000700      03 F021                PICTURE X.                            RON
C 000710      03 F022                PICTURE X.                            RON
C 000720      03 F023.                                                     RON
C 000730         04  F02301          PICTURE X.                            RON
C 000740         04  F02302          PICTURE X.                            RON
C 000750      03 F024                PICTURE X.                            RON
C 000760      03 F025.                                                     RON
C 000770         04  F02501          PICTURE X.                            RON
C 000780         04  F02502          PICTURE X.                            RON
C 000790      03 F026                PICTURE XX.                           RON
C 000800      03 F027                PICTURE X.                            RON
C 000810      03 F028.                                                     RON
C 000820         04  F02801          PICTURE X.                            RON
C 000830         04  F02802          PICTURE X.                            RON
C 000840      03 F029.                                                     RON
C 000850         04  F02901          PICTURE X.                            RON
C 000860         04  F02902          PICTURE X.                            RON
C 000870      03 F030.                                                     RON
C 000880         04  F03001          PICTURE X.                            RON
C 000890         04  F03002          PICTURE X.                            RON
C 000900      03 F031.                                                     RON
C 000910         04  F03101          PICTURE X.                            RON
C 000920         04  F03102          PICTURE X.                            RON
C 000930      03 F032.                                                     RON
C 000940         04  FILLER          PICTURE X(4).                         RON
C 000950         04  F03201          PICTURE X.                            RON
C 000960      03 F033.                                                     RON
C 000970         04  FILLER          PICTURE X(4).                         RON
C 000980         04  F03301          PICTURE X.                            RON
C 000990      03 F034.                                                     RON
C 001000         04  FILLER          PICTURE XX.                           RON
C 001010         04  F03401          PICTURE X.                            RON
C 001020      03 F035.                                                     RON
C 001030         04  FILLER          PICTURE X(13).                        RON
C 001040         04  F03501          PICTURE X.                            RON
C 001050                                                                   RON
C 001060                                                                   RON
C 001070     02  EMGCY-COND.                                               RON
C 001080                                                                   RON
C 001090      03 F036                PICTURE X.                            RON
C 001100      03 F037.                                                     RON
C 001110         04  F03701          PICTURE X.                            RON
C 001120         04  F03702          PICTURE X.                            RON
C 001130      03 F038                PICTURE X.                            RON
C 001140      03 F039                PICTURE X.                            RON
C 001150      03 F040.                                                     RON
C 001160         04  F04001          PICTURE X.                            RON
C 001170         04  F04002          PICTURE X.                            RON
C 001180                                                                   RON
C 001190                                                                   RON
C 001200     02  WEATHER.                                                  RON
C 001210                                                                   RON
C 001220      03 F041                PICTURE X.                            RON
C 001230      03 F042                PICTURE X.                            RON
C 001240      03 F043                PICTURE X.                            RON
C 001250      03 F044                PICTURE X.                            RON
C 001260      03 F045                PICTURE X.                            RON
C 001270      03 F046                PICTURE X.                            RON
C 001280      03 F047                PICTURE X.                            RON
C 001290                                                                   RON
C 001300                                                                   RON
C 001310     02  AIRPORT.                                                  RON
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       03 F048              PICTURE X.
       03 F049              PICTURE X.
       03 F050              PICTURE X(5).
       03 F051              PICTURE X.
       03 F052              PICTURE X(17).
       03 F053              PICTURE X(5).
       03 F054              PICTURE X.
       03 F055              PICTURE X.
       03 F056.
          04  F05601        PICTURE X.
          04  F05602        PICTURE X.
       03 F057              PICTURE X.
       03 F058              PICTURE X.
       03 F059              PICTURE X.
       03 F060              PICTURE X(5).


      02  ITINERARY.

       03 F061.
          04  F06101        PICTURE X.
          04  FILLER        PICTURE X(20).
       03 F062.
          04  F06201        PICTURE X.
          04  FILLER        PICTURE X(20).
       03 F063.
          04  F06301        PICTURE X.
          04  FILLER        PICTURE X(20).


      02  ACC-SITE.

       03 F064.
          04  FILLER        PICTURE X(4).
          04  F06401        PICTURE X.
       03 F065              PICTURE X.


      02  MISC.

       03 F066              PICTURE X.
       03 F067              PICTURE X.
       03 FILLER            PICTURE X.


      02  PILOT-DATA.

       03 F068.
          04  F06801        PICTURE X.
          04  F06802        PICTURE X.
       03 F069.
          04  F06901.
              05  F0690101.
                  06  FILLER          PICTURE X(4).
                  06  F069010101      PICTURE X.
              05  FILLER              PICTURE X.
          04  F06902.
              05  F0690201.
                  06  FILLER          PICTURE X(4).
                  06  F069020101      PICTURE X.
              05  FILLER              PICTURE X.
       03 F070.
          04  F07001.
              05  F0700101.
                  06  FILLER          PICTURE X(4).
                  06  F070010101      PICTURE X.
              05  FILLER              PICTURE X.
          04  F07002.
              05  F0700201.
                  06  FILLER          PICTURE X(4).
                  06  F070020101      PICTURE X.
              05  FILLER              PICTURE X.
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AD-A032 415 LOCKHEED-CALIFORNIA CO BURBANK F/G 1/2

A METHOD OF ANALYSIS FOR GENERAL AVIATION AIRPLANE STRUCTURAL C--ETC(U)

SEP 76 G WITTLIN, M A GAMON DOT-FA75WA-3707

UNCLASSIFIED LR-27698 FAA-RD-76-123 NL

AD A
032 415

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      03 F071.                                                RON
         04  F07101.                                          RON
             05  F0710101.                                    RON
                 06  FILLER         PICTURE X.                RON
                 06  F071010101     PICTURE X.                RON
             05  FILLER             PICTURE X.                RON
         04  F07102.                                          RON
             05  F0710201.                                    RON
                 06  FILLER         PICTURE X.                RON
                 06  F071020101     PICTURE X.                RON
             05  FILLER             PICTURE X.                RON
      03 F072.                                                RON
         04  F07201.                                          RON
             05  F0720101     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
         04  F07202.                                          RON
             05  F0720201     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
      03 F073.                                                RON
         04  F07301.                                          RON
             05  F0730101     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
         04  F07302.                                          RON
             05  F0730201     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
      03 F074.                                                RON
         04  F07401.                                          RON
             05  F0740101     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
         04  F07402.                                          RON
             05  F0740201     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
      03 F075.                                                RON
         04  F07501.                                          RON
             05  F0750101     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
         04  F07502.                                          RON
             05  F0750201     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
      03 F076.                                                RON
         04  F07601.                                          RON
             05  F0760101     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
         04  F07602.                                          RON
             05  F0760201     PICTURE X.                      RON
             05  FILLER       PICTURE X.                      RON
      03 F077                 PICTURE X.                      RON
                                                              RON
                                                              RON
    02  DUM1.                                                 RON
                                                              RON
      03 FILLER          PICTURE X(20).                       RON
                                                              RON
                                                              RON
    02  CAUSE-FACTOR.                                         RON
                                                              RON
      03 F078      OCCURS 17 TIMES.                           RON
         04  F07801        PICTURE XX.                        RON
         04  F07802        PICTURE X.                         RON
         04  F07803.                                          RON
             05  F0780301     PICTURE X.                      RON
             05  F0780302     PICTURE X.                      RON
                                                              RON
                                                              RON
    02  INJRY.                                                RON
                                                              RON
      03 F079              PICTURE X.                         RON
      03 F080A.                                               RON
         04  F08001A OCCURS 3 TIMES.                          RON
             05  F080101A   OCCURS 6 TIMES  PICTURE XXX.      RON
         04  FILLER        PICTURE X(7).                      RON
      03 F080B   OCCURS 4 TIMES.                              RON
         04  F08001B       OCCURS 3 TIMES.                    RON
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            05  F0800101B   OCCURS 6 TIMES  PICTURE XXX.          RON
        04  FILLER          PICTURE X(8).                         RON
     03 F081.                                                     RON
        04  F08101  OCCURS 6 TIMES  PICTURE XXX.                  RON
        04  FILLER          PICTURE X(8).                         RON
                                                                  RON
                                                                  RON
    02  RMRKS.                                                    RON
                                                                  RON
     03 F082.                                                     RON
        04  F08201          PICTURE X.                            RON
        04  F08202          PICTURE X(49).                        RON
     03 FILLER              PICTURE X(11).                        RON
                                                                  RON
                                                                  RON
    02  CAUSE.                                                    RON
                                                                  RON
     03 F083.                                                     RON
        04  F08301  OCCURS 50 TIMES PICTURE X.                    RON
     03 FILLER              PICTURE X(11).                        RON
                                                                  RON
                                                                  RON
    02  DUM2.                                                     RON
                                                                  RON
     03 FILLER              PICTURE X(20).                        RON
                                                                  RON
                                                                  RON
    02  E-P-DATA.                                                 RON
                                                                  RON
     03 F084                PICTURE X.                            RON
     03 F085                PICTURE X.                            RON
     03 F086                PICTURE X.                            RON
     03 F087                PICTURE X.                            RON
     03 F088                PICTURE X.                            RON
     03 F089                PICTURE X.                            RON
                                                                  RON
                                                                  RON
    02  OVERHAUL.                                                 RON
                                                                  RON
     03 F090.                                                     RON
        04  FILLER          PICTURE X(4).                         RON
        04  F09001          PICTURE X.                            RON
     03 F091.                                                     RON
        04  F09101  OCCURS 4 TIMES.                               RON
            05  FILLER          PICTURE XXX.                      RON
            05  F0910101        PICTURE X.                        RON
     03 F092.                                                     RON
        04  F09201  OCCURS 4 TIMES.                               RON
            05  FILLER          PICTURE XXX.                      RON
            05  F0920101        PICTURE X.                        RON
     03 F093.                                                     RON
        04  FILLER              PICTURE X(5).                     RON
        04  F09301              PICTURE X.                        RON
     03 F094.                                                     RON
        04  F09401              PICTURE X.                        RON
        04  FILLER              PICTURE X(11).                    RON
     03 FILLER                  PICTURE X.                        RON
                                                                  RON
                                                                  RON
    02  WEATHER-SITE.                                             RON
                                                                  RON
     03 F095                    PICTURE X.                        RON
     03 F096.                                                     RON
        04  FILLER              PICTURE X(4).                     RON
        04  F09601              PICTURE X.                        RON
     03 F097                    PICTURE X.                        RON
     03 F098.                                                     RON
        04  F09801              PICTURE X.                        RON
        04  F09802              PICTURE X.                        RON
     03 F099                PICTURE X.                            RON
     03 F100                PICTURE X.                            RON
     03 F101                PICTURE XX.                           RON
     03 F102                PICTURE X(4).                         RON
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C        03 F103.                                              RON
C           04  F10301      PICTURE X.                         RON
C           04  F10302      PICTURE X.                         RON
C           04  F10303      PICTURE X.                         RON
C        03 F104            PICTURE XXX.                       RON
C        03 F105            PICTURE XXX.                       RON
C        03 F106.                                              RON
C           04  FILLER      PICTURE XX.                        RON
C           04  F10601      PICTURE X.                         RON
C                                                              RON
C                                                              RON
C       02  AAA.                                               RON
C                                                              RON
C        03 F107            PICTURE X.                         RON
C        03 F108            PICTURE X.                         RON
C        03 F109            PICTURE X.                         RON
C        03 F110            PICTURE X.                         RON
C        03 F111            PICTURE X.                         RON
C        03 F112            PICTURE X.                         RON
C        03 F113            PICTURE X.                         RON
C        03 F114            PICTURE X.                         RON
C        03 F115            PICTURE X.                         RON
C        03 F116            PICTURE X.                         RON
C        03 F117            PICTURE X.                         RON
C        03 F118            PICTURE X.                         RON
C        03 F119            PICTURE X.                         RON
C                                                              RON
C                                                              RON
C       02  DUM3.                                              RON
C                                                              RON
C        03 FILLER          PICTURE X(20).                     RON
C                                                              RON
C                                                              RON
C       02  FLIGHT-DATA.                                       RON
C                                                              RON
C        03 F120.                                              RON
C           04  FILLER      PICTURE XXX.                       RON
C           04  F12001      PICTURE X.                         RON
C        03 F121.                                              RON
C           04  FILLER      PICTURE XXX.                       RON
C           04  F12101      PICTURE X.                         RON
C        03 F122            PICTURE XXX.                       RON
C        03 F123            PICTURE XX.                        RON
C        03 F124.                                              RON
C           04  FILLER      PICTURE XXX.                       RON
C           04  F12401      PICTURE X.                         RON
C        03 F125.                                              RON
C           04  F12501.                                        RON
C               05  FILLER        PICTURE X.                   RON
C               05  F1250101      PICTURE X.                   RON
C           04  F12502.                                        RON
C               05  FILLER        PICTURE XX.                  RON
C               05  F1250201      PICTURE X.                   RON
C           04  F12503.                                        RON
C               05  FILLER        PICTURE XX.                  RON
C               05  F1250301      PICTURE X.                   RON
C        03 F126.                                              RON
C           04  FILLER            PICTURE X.                   RON
C           04  F12601            PICTURE X.                   RON
C        03 F127.                                              RON
C           04  FILLER            PICTURE X.                   RON
C           04  F12701            PICTURE X.                   RON
C        03 F128                  PICTURE XX.                  RON
C        03 F129.                                              RON
C           04  FILLER            PICTURE X(16).               RON
C           04  F12901            PICTURE X.                   RON
C        03 F130.                                              RON
C           04  FILLER            PICTURE X(9).                RON
C           04  F13001            PICTURE X.                   RON
C        03 FILLER                PICTURE X(4).                RON
C                                                              RON
C                                                              RON
C       02  HUMAN-FACTORS.                                     RON
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  C 004240                                                    RON
  C 004250         03 F131.                                   RON
  C 004260            04  F13101         PICTURE X.           RON
  C 004270            04  F13102         PICTURE X.           RON
  C 004280            04  F13103         PICTURE X.           RON
  C 004290            04  F13104         PICTURE X.           RON
  C 004300         03 F132               PICTURE XX.          RON
  C 004310         03 F133.                                   RON
  C 004320            04  F13301         PICTURE X.           RON
  C 004330            04  F13302.                             RON
  C 004340                05  FILLER     PICTURE X.           RON
  C 004350                05  F1330201   PICTURE X.           RON
  C 004360         03 F134               PICTURE X.           RON
  C 004370         03 F135               PICTURE X.           RON
  C 004380         03 F136.                                   RON
  C 004390            04  FILLER         PICTURE XXX.         RON
  C 004400            04  F13601         PICTURE X.           RON
  C 004410         03 F137.                                   RON
  C 004420            04  F13701         PICTURE X.           RON
  C 004430            04  F13702         PICTURE X.           RON
  C 004440            04  F13703         PICTURE X.           RON
  C 004450            04  F13704         PICTURE X.           RON
  C 004460            04  F13705         PICTURE X.           RON
  C 004470         03 F138               PICTURE X.           RON
  C 004480         03 F139.                                   RON
  C 004490            04  FILLER         PICTURE XX.          RON
  C 004500            04  F13901         PICTURE X.           RON
  C 004510         03 F140.                                   RON
  C 004520            04  FILLER         PICTURE XX.          RON
  C 004530            04  F14001         PICTURE X.           RON
  C 004540         03 F141.                                   RON
  C 004550            04  FILLER         PICTURE XX.          RON
  C 004560            04  F14101         PICTURE X.           RON
  C 004570         03 F142               PICTURE X.           RON
  C 004580         03 F143               PICTURE X.           RON
  C 004590         03 F144               PICTURE X.           RON
  C 004600         03 F145               PICTURE X.           RON
  C 004610         03 F146               PICTURE X.           RON
  C 004620         03 F147               PICTURE X.           RON
  C 004630         03 F148.                                   RON
  C 004640            04  F14801         PICTURE X.           RON
  C 004650            04  F14802         PICTURE X.           RON
  C 004660            04  F14803         PICTURE X.           RON
  C 004670            04  F14804         PICTURE X.           RON
  C 004680         03 F149.                                   RON
  C 004690            04  F14901.                             RON
  C 004700                05  FILLER     PICTURE XX.          RON
  C 004710                05  F1490101   PICTURE X.           RON
  C 004720            04  F14902.                             RON
  C 004730                05  FILLER     PICTURE XX.          RON
  C 004740                05  F1490201   PICTURE X.           RON
  C 004750         03 F150               PICTURE X.           RON
  C 004760         03 F151.                                   RON
  C 004770            04  F15101         PICTURE X.           RON
  C 004780            04  F15102         PICTURE X.           RON
  C 004790            04  F15103         PICTURE X.           RON
  C 004800         03 F152.                                   RON
  C 004810            04  FILLER         PICTURE XX.          RON
  C 004820            04  F15201         PICTURE X.           RON
  C 004830         03 F153               PICTURE X.           RON
  C 004840         03 FILLER             PICTURE X(7).        RON
  C 004850                                                    RON
  C 004860                                                    RON
  C 004870        02  FIRE-INFO.                              RON
  C 004880                                                    RON
  C 004890         03 F154               PICTURE X.           RON
  C 004900         03 F155               PICTURE X.           RON
  C 004910         03 F156               PICTURE X.           RON
  C 004920         03 F157               PICTURE X.           RON
  C 004930         03 F158.                                   RON
  C 004940            04  F15801         PICTURE X.           RON
  C 004950            04  F15802.                             RON
  C 004960                05  F1580201   PICTURE X.           RON
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C 004970             05  F1580202     PICTURE X.                    RON
C 004980         04  F15803.                                        RON
C 004990             05  F1580301     PICTURE X.                    RON
C 005000             05  F1580302     PICTURE X.                    RON
C 005010      03 F159                 PICTURE X.                    RON
C 005020      03 F160                 PICTURE X.                    RON
C 005030      03 F161.                                              RON
C 005040         04  F16101           PICTURE X.                    RON
C 005050         04  F16102           PICTURE X.                    RON
C 005060                                                            RON
C 005070                                                            RON
C 005080     02  EQUIP.                                             RON
C 005090                                                            RON
C 005100      03 F162                 PICTURE X.                    RON
C 005110      03 F163                 PICTURE X.                    RON
C 005120      03 F164.                                              RON
C 005130         04  F16401           PICTURE X.                    RON
C 005140         04  F16402           PICTURE X.                    RON
C 005150      03 F165                 PICTURE X.                    RON
C 005160      03 F166                 PICTURE X.                    RON
C 005170                                                            RON
C 005180                                                            RON
C 005190     02 W-B-DAMAGE.                                         RON
C 005200                                                            RON
C 005210      03 F167                 PICTURE X.                    RON
C 005220      03 F168                 PICTURE X.                    RON
C 005230      03 F169                 PICTURE X.                    RON
C 005240      03 F170                 PICTURE X.                    RON
C 005250      03 F171                 PICTURE X.                    RON
C 005260      03 F172                 PICTURE X.                    RON
C 005270      03 F173                 PICTURE X.                    RON
C 005280      03 F174.                                              RON
C 005290         04  F17401           PICTURE X.                    RON
C 005300         04  F17402           PICTURE X.                    RON
C 005310      03 F175                 PICTURE X.                    RON
C 005320      03 F176                 PICTURE X.                    RON
C 005330      03 F177.                                              RON
C 005340         04  F17701           PICTURE X.                    RON
C 005350         04  F17702           PICTURE X.                    RON
C 005360      03 F178                 PICTURE X.                    RON
C 005370      03 F179                 PICTURE X.                    RON
C 005380      03 F180                 PICTURE X.                    RON
C 005390      03 F181                 PICTURE X.                    RON
C 005400      03 F182                 PICTURE X.                    RON
C 005410      03 F183                 PICTURE X.                    RON
C 005420                                                            RON
C 005430                                                            RON
C 005440     02  DUM4.                                              RON
C 005450                                                            RON
C 005460      03 FILLER               PICTURE X(23).                RON
C 005470      03 FILLER               PICTURE X(20).                RON
C 005480                                                            RON
C 005490                                                            RON
C 005500     02  ADMIN-DATA.                                        RON
C 005510                                                            RON
C 005520      03 FILLER               PICTURE XXX.                  RON
C 005530      03 F184                 PICTURE X(12).                RON
C 005540      03 F185                 PICTURE X(6).                 RON
C 005550      03 F186     OCCURS 3 TIMES.                           RON
C 005560         04  F18601           PICTURE 99.                   RON
C 005570         04  F18602           PICTURE XX.                   RON
C 005580         04  F18603           PICTURE XX.                   RON
C 005590      03 F187                 PICTURE 99.                   RON
C 005600      03 F188                 PICTURE XXX.                  RON
C 005610      03 F189                 PICTURE X(13).                RON
C 005620                                                            RON
C 005630                                                            RON
C 005640     02  IDN.                                               RON
C 005650                                                            RON
C 005660      03 F190                 PICTURE X(4).                 RON
C 005670                                                            RON
C 005680                                                            RON
C 005690     02  DUM5.                                              RON
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C                                                        RON
C      03 FILLER                   PICTURE X(20).        RON
C                                                        RON
C                                                        RON
C     02  AERIAL-APP.                                    RON
C                                                        RON
C      03 F191.                                          RON
C          04  FILLER              PICTURE XXX.          RON
C          04  F19101              PICTURE X.            RON
C      03 F192                     PICTURE X.            RON
C      03 F193                     PICTURE X.            RON
C      03 F194                     PICTURE X.            RON
C      03 F195                     PICTURE X.            RON
C      03 F196                     PICTURE X.            RON
C      03 F197                     PICTURE X.            RON
C      03 F198                     PICTURE X.            RON
C      03 F199                     PICTURE X.            RON
C      03 F200                     PICTURE X.            RON
C      03 F201                     PICTURE X.            RON
C      03 F202                     PICTURE X.            RON
C      03 F203                     PICTURE X.            RON
C      03 F204                     PICTURE X.            RON
C      03 F205                     PICTURE X.            RON
C      03 F206                     PICTURE X.            RON
C      03 F207                     PICTURE X.            RON
C      03 F208                     PICTURE X(5).         RON
C      03 F209.                                          RON
C          04  F20901              PICTURE X.            RON
C          04  F20902              PICTURE X.            RON
C          04  F20903              PICTURE X.            RON
C      03 F210.                                          RON
C          04  F21001              PICTURE X.            RON
C          04  F21002              PICTURE X.            RON
C          04  F21003              PICTURE X.            RON
C      03 F211                     PICTURE X.            RON
C      03 F212                     PICTURE X.            RON
C                                                        RON
C                                                        RON
C     02  DUM6.                                          RON
C                                                        RON
C      03 FILLER                   PICTURE X(28).        RON
C      03 FILLER                   PICTURE X(20).        RON
C                                                        RON
C                                                        RON
C     02  COL.                                           RON
C                                                        RON
C      03 F213                     PICTURE X.            RON
C      03 F214                     PICTURE X.            RON
C      03 F215                     PICTURE X.            RON
C      03 F216                     PICTURE X.            RON
C      03 F217                     PICTURE X.            RON
C      03 F218                     PICTURE X.            RON
C      03 F219                     PICTURE X.            RON
C      03 F220                     PICTURE XXX.          RON
C      03 F221                     PICTURE XXX.          RON
C      03 F222.                                          RON
C          04  F22201              PICTURE XXX.          RON
C          04  F22202              PICTURE XXX.          RON
C      03 F223                     PICTURE X.            RON
C      03 F224                     PICTURE X.            RON
C      03 F225                     PICTURE X.            RON
C      03 F226                     PICTURE X.            RON
C      03 F227                     PICTURE X.            RON
C                                                        RON
C                                                        RON
C     02  DUM7.                                          RON
C                                                        RON
C      03 FILLER                   PICTURE X(37).        RON
C                                                        RON
C                                                        RON
C     02  DITCH-SURVIVAL.                                RON
C                                                        RON
C      03 F228                     PICTURE X.            RON
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C 006430         03 F229                     PICTURE XX.                        RON
C 006440         03 F230.                                                       RON
C 006450            04  F23001               PICTURE XX.                        RON
C 006460            04  F23002               PICTURE XXX.                       RON
C 006470         03 F231                     PICTURE X.                         RON
C 006480         03 F232                     PICTURE X.                         RON
C 006490         03 FILLER                   PICTURE X.                         RON
C 006500         03 F233                     PICTURE X.                         RON
C 006510         03 F234                     PICTURE X.                         RON
C 006520         03 F235                     PICTURE X.                         RON
C 006530         03 F236                     PICTURE X.                         RON
C 006540         03 F237                     PICTURE X.                         RON
C 006550         03 F238                     PICTURE X.                         RON
C 006560         03 F239                     PICTURE X.                         RON
C 006570        02  DUM6.                                                       RON
C 006580         03 FILLER                   PICTURE X(127).                    RON
  004100 WORKING-STORAGE SECTION.
  004200 77   ADD-TOT-AC                     PIC X.
  004300 77   ANGLE-SUM                             PIC 9(7) VALUE ZERO.
  004400 77   ANGLE-15                              PIC 9(5) VALUE ZERO.
  004500 77   ANGLE-30                              PIC 9(5) VALUE ZERO.
  004600 77   ANGLE-45                              PIC 9(5) VALUE ZERO.
  004700 77   ANGLE-60                              PIC 9(5) VALUE ZERO.
  004800 77   ANGLE-75                              PIC 9(5) VALUE ZERO.
  004900 77   ANGLE-90                              PIC 9(5) VALUE ZERO.
  005000 77   ANGLE-90-PLUS                         PIC 9(5) VALUE ZERO.
  005100 77   AV-OCC                     PIC 9(5) VALUE ZERO.
  005200 77   AVG-ANGLE                             PIC 9999 VALUE ZERO.
  005300 77   AVG-DIST                              PIC 9999 VALUE ZERO.
  005400 77   AVG-VEL                               PIC 9999    VALUE ZERO.
  005500 77   BEEN-THERE                 PIC X.
  005600 77   C-HI          PIC 9(3).
  005700 77   C-INITIAL          PIC 9(3).
  005800 77   C-SAVE                     PIC 9(3) VALUE ZERO.
  005900 77   C-SV                       PIC 9 VALUE 1.
  006000 77   C-SV-LIMIT                 PIC 9.
  006100 77   C-TEST           PIC 9 VALUE 1.
  006200 77   CAUSE-FACTOR-77                       PIC 9(4).
  006300 77   CAUSE-77                   PIC 9(5) VALUE ZERO.
  006400 77   CFF                            PIC 99.
  006500 77   D                              PIC 99 VALUE 01.
  006600 77   DIST-SUM                              PIC 9(6)  VALUE ZERO.
  006700 77   DIST-10                               PIC 9(5)  VALUE ZERO.
  006800 77   DIST-20                               PIC 9(5)  VALUE ZERO.
  006900 77   DIST-30                               PIC 9(5)  VALUE ZERO.
  007000 77   DIST-40                               PIC 9(5)  VALUE ZERO.
  007100 77   DIST-50                               PIC 9(5)  VALUE ZERO.
  007200 77   DIST-60                               PIC 9(5)  VALUE ZERO.
  007300 77   DIST-60-PLUS                          PIC 9(5)  VALUE ZERO.
  007400 77   DIVIDE-HOLD          PIC 9(4) USAGE COMP SYNC VALUE 0.
  007500 77   DIVIDEND-HOLD        PIC 9(5) USAGE COMP SYNC VALUE 0.
  007600 77   DUMBO                          PIC X.
  007700 77   ERR     PIC X(20).
  007800 77   ERR-RT PIC X(20).
  007900 77   F                          PIC 9(3) VALUE ZERO.
  008000 77   FACTOR-SAVE                PIC XX.
  008100 77   FACTOR-77                  PIC XX.
  008200 77   FAT-INFLT         PIC 9(5) VALUE ZERO.
  008300 77   FAT-LOG           PIC 9(5) VALUE ZERO.
  008400 77   FAT-NR                                PIC 9(5) VALUE ZERO.
  008500 77   FAT-TO            PIC 9(5) VALUE ZERO.
  008600 77   FAT-TS                                PIC 9(5) VALUE ZERO.
  008700 77   FDATA                          PIC X(68).
  008800 77   FOUND-WORD                 PIC X VALUE '0'.
  008900 77   G-ANG-SUM                  PIC 9(6) VALUE ZERO.
  009000 77   G-ANG-15                   PIC 9(5) VALUE ZERO.
  009100 77   G-ANG-30                   PIC 9(5) VALUE ZERO.
  009200 77   G-ANG-45                   PIC 9(5) VALUE ZERO.
  009300 77   G-ANG-60                   PIC 9(5) VALUE ZERO.
  009400 77   G-ANG-75                   PIC 9(5) VALUE ZERO.
  009500 77   G-ANG-90                   PIC 9(5) VALUE ZERO.
  009600 77   G-ANG-90-PLUS              PIC 9(5) VALUE ZERO.
  009700 77   G-AVG-ANGLE        PIC 9999 VALUE ZERO.
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009800 77  G-AVG-DIST      PIC 9999 VALUE ZERO.
009900 77  G-AVG-VEL     PIC 9999 VALUE ZERO.
010000 77  G-DIST-SUM              PIC 9(6) VALUE ZERO.
010100 77  G-DIST-10               PIC 9(5) VALUE ZERO.
010200 77  G-DIST-20               PIC 9(5) VALUE ZERO.
010300 77  G-DIST-30               PIC 9(5) VALUE ZERO.
010400 77  G-DIST-40               PIC 9(5) VALUE ZERO.
010500 77  G-DIST-50               PIC 9(5) VALUE ZERO.
010600 77  G-DIST-60               PIC 9(5) VALUE ZERO.
010700 77  G-DIST-60-PLUS          PIC 9(5) VALUE ZERO.
010800 77  G-VEL-SUM               PIC 9(6) VALUE ZERO.
010900 77  G-VEL-120               PIC 9(5) VALUE ZERO.
011000 77  G-VEL-120-PLUS          PIC 9(5) VALUE ZERO.
011100 77  G-VEL-30                PIC 9(5) VALUE ZERO.
011200 77  G-VEL-60                PIC 9(5) VALUE ZERO.
011300 77  G-VEL-90                PIC 9(5) VALUE ZERO.
011400 77  GAVG-OCC                PIC 9(5) VALUE ZERO.
011500 77  GFAT-INFLT                  PIC 9(5) VALUE ZERO.
011600 77  GFAT-LOG                    PIC 9(5) VALUE ZERO.
011700 77  GFAT-NR                         PIC 9(5) VALUE ZERO.
011800 77  GFAT-TO                     PIC 9(5) VALUE ZERO.
011900 77  GFAT-TS                         PIC 9(5) VALUE ZERO.
012000 77  GHEL-UNUSED             PIC 9(5) VALUE ZERO.
012100 77  GHEL-USED               PIC 9(5) VALUE ZERO.
012200 77  GS-H-FAILED             PIC 9(5) VALUE ZERO.
012300 77  GS-H-INST               PIC 9(5) VALUE ZERO.
012400 77  GS-H-USED               PIC 9(5) VALUE ZERO.
012500 77  GTOT-AC                 PIC 9(5) VALUE ZERO.
012600 77  GTOT-AC-TYPE                PIC 9(5) VALUE ZERO.
012700 77  GTOT-ACC-ANG            PIC 9(5) VALUE ZERO.
012800 77  GTOT-ACC-DIST           PIC 9(5) VALUE ZERO.
012900 77  GTOT-ACC-VEL            PIC 9(5) VALUE ZERO.
013000 77  GTOT-FAT                PIC 9(5) VALUE ZERO.
013100 77  GTOT-FLY                    PIC 9(5) VALUE ZERO.
013200 77  GTOT-LOG                    PIC 9(5) VALUE ZERO.
013300 77  GTOT-MNR                PIC 9(5) VALUE ZERO.
013400 77  GTOT-NON                PIC 9(5) VALUE ZERO.
013500 77  GTOT-NR                         PIC 9(5) VALUE ZERO.
013600 77  GTOT-OCC                PIC 9(5) VALUE ZERO.
013700 77  GTOT-SER                PIC 9(5) VALUE ZERO.
013800 77  GTOT-ST-ACC             PIC 9(5) VALUE ZERO.
013900 77  GTOT-ST-FAIL            PIC 9(5) VALUE ZERO.
014000 77  GTOT-STBLT-ACC          PIC 9(5) VALUE ZERO.
014100 77  GTOT-STBLT-FAIL         PIC 9(5) VALUE ZERO.
014200 77  GTOT-T-O                    PIC 9(5) VALUE ZERO.
014300 77  GTOT-TS                         PIC 9(5) VALUE ZERO.
014400 77  HD      PIC X(20).
014500 77  HEAD-COUNT      PIC 9(5) VALUE 0.
014600 77  HELMET-UNUSED                   PIC 9(5) VALUE ZERO.
014700 77  HELMET-USED                     PIC 9(5) VALUE ZERO.
014800 77  HI                      PIC 999 VALUE ZERO.
014900 77  HISAVE                  PIC 999.
015000 77  HOLD-MAKE               PIC X(3) VALUE LOW-VALUE.
015100 77  HOLD-MAKE-NAME              PIC X(11).
015200 77  HOLD-MODEL              PIC XX   VALUE LOW-VALUE.
015300 77  HOLD-YEAR               PIC XX VALUE LOW-VALUE.
015400 77  I                       PIC 999 VALUE ZERO.
015500 77  INDEX-HOLD      PIC 9(5) VALUE ZERO.
015600 77  INJ1                        PIC 99 VALUE 1.
015700 77  INJ2                        PIC 99.
015800 77  ITER-4      PIC 9(5) VALUE ZERO.
015900 77  J                       PIC 99   VALUE ZERO.
016000 77  LO                      PIC 999 VALUE ZERO.
016100 77  NTSBXY1                 PIC 9(3).
016200 77  NTSBXY2                 PIC 9(3).
016300 77  NTSBXY3                 PIC 9(3).
016400 77  NTSBXY4                 PIC 9(3).
016500 77  NTSB9                   PIC 9.
016600 77  OP                              PIC 99 VALUE ZERO.
016700 77  OP-PH-HOLD              PIC 9(5).
016800 77  PCNTT               PIC 99999.
016900 77  PCT-HOLD          PIC X(5).
017000 77  PERCNT      PIC X(8) VALUE ' %      '.
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 77  PRINT-ID               PIC X.
 77  READER-SWITCH           PIC X.
 77  REC-TOT-CCC                  PIC 9(3) VALUE ZERO.
 77  REPLY-77                           PIC X(4) VALUE SPACES.
 77  S-H-FAILED                         PIC 9(5) VALUE ZERO.
 77  S-H-INSTALLED                      PIC 9(5) VALUE ZERO.
 77  S-H-USED                           PIC 9(5) VALUE ZERO.
 77  S-SUB                  PIC 9 VALUE ZERO.
 77  SAV-CARD                     PIC X(9) VALUE SPACES.
 77  SEARCH-CODE                        PIC XX.
 77  SEARCH-TYPE                        PIC X.
 77  SEARCH-WORD            PIC X(5).
 77  SER-IND       PIC 99.
 77  SER-SUB                PIC 9 VALUE 1.
 77  SEV-IND           PIC 99.
 77  SEVERITY-77                  PIC X(5) VALUE 'ABCDE'.
 77  SPACE-LINE                         PIC X(132) VALUE SPACES.
 77  SS                     PIC 99.
 77  SSS                    PIC 99.
 77  SUM-A      PIC 9(18) USAGE COMP SYNC VALUE 0.
 77  SUMMARY-COUNTER             PIC 9(6) VALUE ZERO.
 77  SUMMARY-HEAD-1 PIC X(89) VALUE '
-    '                         * * * * * ACCIDENT SUMMARY  * * * * *'.
 77  SUMMARY-HEAD-2 PIC X(69) VALUE '
-    '                                          FOR'.
 77  TER-IND                PIC 99.
 77  TERRAIN-77                   PIC X(13) VALUE 'ABCDEFGHIJKYZ'.
 77  TOT-AC                 PIC 9(5) VALUE ZERO.
 77  TOT-AC-TYPE                  PIC 9(5) VALUE ZERO.
 77  TOT-ACC-ANG                        PIC 9(5) VALUE ZERO.
 77  TOT-ACC-VEL                        PIC 9(5) VALUE ZERO.
 77  TOT-ACC-DIST                       PIC 9(5)  VALUE ZERO.
 77  TOT-FAT                PIC 9(5) VALUE ZERO.
 77  TOT-FLY                            PIC 9(5) VALUE ZERO.
 77  TOT-LDG                            PIC 9(5) VALUE ZERO.
 77  TOT-MNR                PIC 9(5) VALUE ZERO.
 77  TOT-NON                PIC 9(5) VALUE ZERO.
 77  TOT-NR                             PIC 9(5) VALUE ZERO.
 77  TOT-OCC                PIC 9(5) VALUE ZERO.
 77  TOT-SER                PIC 9(5) VALUE ZERO.
 77  TOT-ST-ACC                         PIC 9(5) VALUE ZERO.
 77  TOT-ST-FAIL                        PIC 9(5) VALUE ZERO.
 77  TOT-STBLT-ACC                      PIC 9(5) VALUE ZERO.
 77  TOT-STBLT-FAIL                     PIC 9(5) VALUE ZERO.
 77  TOT-T-O                            PIC 9(5) VALUE ZERO.
 77  TOT-TS                             PIC 9(5) VALUE ZERO.
 77  TYP-HOLD               PIC 9(5).
 77  TYPES-77                     PIC X(12) VALUE 'DEFLPRO12457'.
 77  VEL-SUM                            PIC 9(6) VALUE ZERO.
 77  VEL-120                            PIC 9(5) VALUE ZERO.
 77  VEL-120-PLUS                       PIC 9(5) VALUE ZERO.
 77  VEL-30                             PIC 9(5) VALUE ZERO.
 77  VEL-60                             PIC 9(5) VALUE ZERO.
 77  VEL-90                             PIC 9(5) VALUE ZERO.
 77  PCNT-OCC           PIC 999V99.
 01  HOLD-KEY.
     02  HOLD-KEY-1               PIC XX.
     02  HOLD-KEY-2               PIC XX.
 01  P-WORK.
     02  P-WORK-02A.
     03  FILLER                   PIC X(10) VALUE SPACES.
     03  DESCRIPTION              PIC X(48).
     03  FILLER                   PIC X(3) VALUE SPACES.
     03  DATAA                    PIC X(68).
     03  FILLER                   PIC X(6) VALUE SPACES.
     02  P-WORK-02C REDEFINES P-WORK-02A.
         03  FILL-ER          PIC X.
         03  P-WORK-02B           PIC X(131).
 01  TERRAIN-001.
     02  TERRAIN-COUNT OCCURS 13 TIMES   PIC 9(4).

 01  HD-KEY-ACT.
     02  HD-KEY.
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                03  CCC.
                    04  CC    PIC X(4).
                    04  C     PIC XX.
                03  FILL      PIC XX.
                03  CODE4.
                    04  CHAR4    PIC X.
                    04  CODE3.
                        05  CHAR3    PIC X.
                        05  CODE2.
                            06  CHAR2    PIC X.
                            06  CHAR1    PIC X.
            02  HD-KEY-TWO REDEFINES HD-KEY.
                10  KYA               PIC 9(10) USAGE COMP.
                10  KYB               PIC 9(6)  USAGE COMP.
        01  DATE-HOLD-01A.
            02  MO                    PIC XX.
            02  DA                    PIC XX.
            02  YR                    PIC XX.
        01  DATE-HOLD-01B.
            02  MO-B                  PIC XX.
            02  FILLER                PIC X VALUE '/'.
            02  DA-B                  PIC XX.
            02  FILLER                PIC X VALUE '/'.
            02  YR-B                  PIC XX.
        01  TYPES-01.
            02  TYPES-02                  PIC X(12).
            02  TYYP REDEFINES TYPES-02 OCCURS 12 TIMES PIC X.
        01  SERIOUSNESS.
            02  SER OCCURS 5 TIMES INDEXED BY S-INDEX.
                03  S OCCURS 4 TIMES INDEXED BY SERIOUS-INDEX PIC 9(5).
        01  ATT-WORK.
            02  ATT-02                PIC X(20).
            02  FILLER                PIC X(48).
        01  ATTITUDE.
            02  ATTITUDE-1                PIC X(20).
            02  FILLER                    PIC XX VALUE ', '.
            02  ATTITUDE-2                PIC X(20).
            02  FILLER                    PIC XX VALUE ', '.
            02  ATTITUDE-3                PIC X(20).
        01  DESCRIPTION-01.
            02  DESCRIPTION-02.
                03  FILLER PIC X(48) VALUE
                    'DATE . . . . . . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48) VALUE
                    'AIRCRAFT MAKE . . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48) VALUE
                    'AIRCRAFT MODEL . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48) VALUE
                    'AIRCRAFT DAMAGE . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'FIRE AFTER IMPACT . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'KIND OF FLYING (GENERAL AVIATION) . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'TYPE OF ACCIDENT, FIRST . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'PHASE OF OPERATION, FIRST . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'TYPE OF ACCIDENT, SECOND  . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'PHASE OF OPERATION, SECOND  . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'AIRCRAFT SPEED . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'AIRPORT PROXIMITY . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'RUNWAY COMPOSITION . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'RUNWAY SURFACE . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'RUNWAY HAZARDS . . . . . . . . . . . . . . . . .'.
                03  FILLER PIC X(48)  VALUE
                    'RUNWAY LENGTH . . . . . . . . . . . . . . . . . .'.
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031700     03  FILLER PIC X(48)  VALUE
               'TERRAIN (TYPE) OF AIRPORT . . . . . . . . . . . . . .'.
031900     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
032100     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
032300     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
032500     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
032700     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
032900     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
033100     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
033300     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
033500     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
033700     03  FILLER PIC X(48)  VALUE
               'CAUSE / FACTOR . . . . . . . . . . . . . . . . . . .'.
033900     03  FILLER PIC X(48)  VALUE
               'PILOT . . . . . . . . . . . . . . . . . . . . . . . .'.
034100     03  FILLER PIC X(48)  VALUE
               'COPILOT . . . . . . . . . . . . . . . . . . . . . . .'.
034300     03  FILLER PIC X(48)  VALUE
               'DUAL PILOT . . . . . . . . . . . . . . . . . . . . .'.
034500     03  FILLER PIC X(48)  VALUE
               'CHECK PILOT . . . . . . . . . . . . . . . . . . . . .'.
034700     03  FILLER PIC X(48)  VALUE
               'PASSENGERS . . . . . . . . . . . . . . . . . . . . .'.
034900     03  FILLER PIC X(48)  VALUE
               'TOTAL ABOARD . . . . . . . . . . . . . . . . . . . .'.
035100     03  FILLER PIC X(48)  VALUE
               'REMARKS . . . . . . . . . . . . . . . . . . . . . . .'.
035300     03  FILLER PIC X(48)  VALUE
035400         '                                                    '.
035500     03  FILLER PIC X(48)  VALUE
               'AIRCRAFT SERIAL NUMBER . . . . . . . . . . . . . . .'.
035700     03  FILLER PIC X(48)  VALUE
               'IMPACT SEVERITY . . . . . . . . . . . . . . . . . . .'.
035900     03  FILLER PIC X(48)  VALUE
               'IMPACT ANGLE . . . . . . . . . . . . . . . . . . . .'.
036100     03  FILLER PIC X(48)  VALUE
               'RATE OF DECELERATION . . . . . . . . . . . . . . . .'.
036300     03  FILLER PIC X(48)  VALUE
               'DIRECTION OF PRINCIPLE DECELERATION . . . . . . . .'.
036500     03  FILLER PIC X(48)  VALUE
               'STOPPING DISTANCE . . . . . . . . . . . . . . . . . .'.
036700     03  FILLER PIC X(48)  VALUE
               'DAMAGE SEVERITY - IMPACT (NON-TRANS. AIRCRAFT)  '.
036900     03  FILLER PIC X(48)  VALUE
               'SEATING CONFIGURATION . . . . . . . . . . . . . . . .'.
037100     03  FILLER PIC X(48)  VALUE
               'SEAT FAILURES - NUMERICAL SUMMARY . . . . . . . .'.
037300     03  FILLER PIC X(48)  VALUE
               'SEAT BELT FAILURES - NUMERICAL SUMMARY  . . . . .'.
037500     03  FILLER PIC X(48)  VALUE
               'DEATH RESULTING FROM FIRE  AFTER IMPACT . . . . .'.
037700     03  FILLER PIC X(48)  VALUE
               'ATTITUDE AT IMPACT - ROLL . . . . . . . . . . . . . .'.
037900     03  FILLER PIC X(48)  VALUE
               'ATTITUDE AT IMPACT - PITCH  . . . . . . . . . . . .'.
038100     03  FILLER PIC X(48)  VALUE
               'ATTITUDE AT IMPACT - YAW  . . . . . . . . . . . . .'.
038300     03  FILLER PIC X(48)  VALUE
               'SPEED AT IMPACT - KNOTS . . . . . . . . . . . . . . .'.
038500     03  FILLER PIC X(48)  VALUE
               'KIND OF OPERATION . . . . . . . . . . . . . . . . . .'.
038700     03  FILLER PIC X(48)  VALUE
               'SHOULDER HARNESS . . . . . . . . . . . . . . . . . .'.
038900     03  FILLER PIC X(48)  VALUE
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                   'SEAT BELT . . . . . . . . . . . . . . . . . . . . . . '.
             03  FILLER PIC X(48)  VALUE
                   'CRASH HELMET . . . . . . . . . . . . . . . . . . . . '.
             03  FILLER PIC X(48)  VALUE
                   'COCKPIT CRASH PAD . . . . . . . . . . . . . . . . . '.
             03  FILLER PIC X(48)  VALUE
                   'CRASH BAR . . . . . . . . . . . . . . . . . . . . . '.
             03  FILLER PIC X(48)  VALUE
                   'OBSTRUCTIONS . . . . . . . . . . . . . . . . . . . '.
             03  FILLER PIC X(48)  VALUE
                   'TERRAIN TYPE . . . . . . . . . . . . . . . . . . . '.
         02  DESC REDEFINES DESCRIPTION-02 OCCURS 70 TIMES PIC X(48).
      01 ACT-KEY.
         05  TRACK-ID   PIC S9(8) USAGE COMP SYNC VALUE 0.
         05  SYMBOLIC-KEY.
             10  KYF    PIC X(6).
             10  FILLER    PIC XX VALUE SPACES.
             10  KYG     PIC X(4).
      01 TERRAIN-01.
         02  TERRAIN-02      PIC X(13).
         02  TERRAIN REDEFINES TERRAIN-02 OCCURS 13 TIMES
             INDEXED BY TERRAIN-INDEX PIC X.
      01 SEVERITY.
         02  SEVERITY-02     PIC X(5).
         02  SEV REDEFINES SEVERITY-02 OCCURS 5 TIMES
             INDEXED BY SEVERITY-INDEX PIC X.
      01 NTSB-WORK.
         02  FILLER    PIC X(1600).
      01 INJ-01.
         02  INJ-02    PIC X(3).
         02  INJURY REDEFINES INJ-02 PIC 9(3).
      01 DIST-01.
         02  DIST-02                        PIC 9(4).
      01 S-01.
         02  SEAT                           PIC 9(3).
      01 MK-MOD.
         02 MK                              PIC XXX.
         02 MOD                             PIC XX.
      01 S-B-01.
         02  SEAT-BELT                      PIC 9(3).
      01 ANGLE-01.
         02  ANGLE-02                       PIC 99.
      01 VEL-01.
         02  VEL-02                         PIC 9(3).
      01 TYP-OP-01.
         02  TYP-OP-02                      PIC X(22)  VALUE 'ABCGHIJKMNQSTUV
-                                          'WXYZ367'.
         02  TYP-OP REDEFINES               TYP-OP-02 OCCURS 22 TIMES PIC X.
      01 TYP-TOT-01.
             03  TYP-TOT-03                 OCCURS 23 TIMES.
                 04  TYP-TOT                OCCURS 5 TIMES PIC 9(5).
      01 OP-PH-TOT.
             03  OP-PH-03                   OCCURS 43 TIMES.
                 04  OP-PH-04               OCCURS 5 TIMES PIC 9(5).
      01 CAUSE-01.
             02 CAUSE-492 OCCURS 487 TIMES PIC 9(5).
      01 CAUSE-FATAL-01.
             02 CAUSE-FATAL OCCURS 487 TIMES PIC 9(5).
      01 CAUSE-NONFAT-01.
             02 CAUSE-NON-FAT OCCURS 487 TIMES PIC 9(5).
      01 PAGE-1-01.
         02  PAGE-1-02.
             03  PAGE-1-03A.
                 04 FILLER PIC X(32) VALUE
                   'AIRCRAFT MANUFACTURER / MODEL - '.
                 04  PAGE-1-MAKE        PIC X(11).
                 04  FILLER             PIC X(3) VALUE ' / '.
                 04  PAGE-1-MOD         PIC X(6).
                 04  FILLER             PIC X(16) VALUE SPACES.
             03  PAGE-1-03C.
                 04  FILLER  PIC X(34) VALUE 'MAXIMUM TO WEIGHT -
-                '     POUNDS'
                 04  FILLER  PIC X(34) VALUE SPACES
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046300     03  FILLER PIC X(68) VALUE 'WING CONFIGURATION
046400-    '                                          '.
046500     03  FILLER PIC X(68) VALUE 'NUMBER OF ENGINES / LOCATION
046600-    '-                                         '.
046700     03  FILLER PIC X(68) VALUE 'GENERAL INFORMATION
046800-    '                                          '.
046900     03  PAGE-1-03D.
047000         04 FILLER PIC X(63) VALUE  '   TOTAL NUMBER OF ACCID
047100-           'ENTS SURVEYED - - - - - - - - - - - - - - '.
047200         04  PG-1-TOTA          PIC Z(5).
047300     03  PAGE-1-03DB.
047400         04  FILLER PIC X(63) VALUE  '   TOTAL APPLICABLE ACCI
047500-           'DENTS SURVEYED - - - - - - - - - - - - - '.
047600         04  PG-1-TOTAB         PIC Z(5).
047700     03  PAGE-1-03E.
047800         04  FILLER PIC X(63) VALUE '   TOTAL NUMBER OF OCCUPA
047900-           'NTS - - - - - - - - - - - - - - - - - - - '.
048000         04  PG-1-TOTB          PIC Z(5).
048100     03  PAGE-1-03F.
048200         04  FILLER PIC X(63) VALUE '   AVERAGE NUMBER OF OCCU
048300-           'PANTS PER ACCIDENT  - - - - - - - - - - '.
048400         04  PG-1-TOTC          PIC Z(5).
048500     03  PAGE-1-03G.
048600         04  FILLER PIC X(63) VALUE '   NUMBER OF ACCIDENTS WI
048700-           'TH AT LEAST ONE (1) FATAL INJURY  - - '.
048800         04  PG-1-TOTD          PIC Z(5).
048900     03  PAGE-1-03H.
049000         04  FILLER PIC X(63) VALUE '   NUMBER OF ACCIDENTS WI
049100-           'TH AT LEAST ONE (1) SERIOUS INJURY  - '.
049200         04  PG-1-TOTE          PIC Z(5).
049300     03  FILLER PIC X(68) VALUE '        AND NONE MORE SERIOUS
049400-    '                                          '.
049500     03  PAGE-1-03J.
049600         04  FILLER PIC X(63) VALUE '   NUMBER OF ACCIDENTS WI
049700-           'TH AT LEAST ONE (1) MINOR INJURY  - - '.
049800         04  PG-1-TOTF          PIC Z(5).
049900     03  FILLER PIC X(68) VALUE '        AND NONE MORE SERIOUS
050000-    '                                          '.
050100     03  PAGE-1-03L.
050200         04  FILLER PIC X(63) VALUE '   NUMBER OF ACCIDENTS WI
050300-           'TH NO INJURY - - - - - - - - - - - - - - '.
050400         04  PG-1-TOTH          PIC Z(5).
050500     03  FILLER PIC X(68) VALUE '        AND NONE MORE SERIOUS
050600-    '                                          '.
050700     03  FILLER PIC X(68) VALUE '            *****  TOTALS OF SER
050800-    'IOUSNESS OF INJURIES  *****               '.
050900     03  FILLER PIC X(68) VALUE '                        FATAL   SE
051000-    'RIOUS   MINOR   NONE                      '.
051100     03  PAGE-1-03M.
051200         04  FILLER PIC X(19) VALUE '        PILOT       '.
051300         04  PG-1-TOTI          PIC Z(5).
051400         04  FILLER             PIC X(4) VALUE SPACES.
051500         04  PG-1-TOTJ          PIC Z(5).
051600         04  FILLER             PIC X(4) VALUE SPACES.
051700         04  PG-1-TOTK          PIC Z(5).
051800         04  FILLER             PIC X(4) VALUE SPACES.
051900         04  PG-1-TOTL          PIC Z(5).
052000         04  FILLER             PIC X(17) VALUE SPACES.
052100     03  PAGE-1-03N.
052200         04  FILLER PIC X(19) VALUE '       COPILOT     '.
052300         04  PG-1-TOTM          PIC Z(5).
052400         04  FILLER             PIC X(4) VALUE SPACES.
052500         04  PG-1-TOTN          PIC Z(5).
052600         04  FILLER             PIC X(4) VALUE SPACES.
052700         04  PG-1-TOTP          PIC Z(5).
052800         04  FILLER             PIC X(4) VALUE SPACES.
052900         04  PG-1-TOTQ          PIC Z(5).
053000         04  FILLER             PIC X(17) VALUE SPACES.
053100     03  PAGE-1-03P.
053200         04  FILLER PIC X(19) VALUE '       PASSENGERS  '.
053300         04  PG-1-TOTR          PIC Z(5).
053400         04  FILLER             PIC X(4) VALUE SPACES.
053500         04  PG-1-TOTS          PIC Z(5).
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053600                04  FILLER             PIC X(4) VALUE SPACES.
053700                04  PG-1-TOTT          PIC Z(5).
053800                04  FILLER             PIC X(4) VALUE SPACES.
053900                04  PG-1-TOTU          PIC Z(5).
054000                04  FILLER             PIC X(17) VALUE SPACES.
054100            03  PAGE-1-03Q.
054200                04  FILLER PIC X(19) VALUE '     * OTHER        '.
054300                04  PG-1-TOTV          PIC Z(5).
054400                04  FILLER             PIC X(4) VALUE SPACES.
054500                04  PG-1-TOTW          PIC Z(5).
054600                04  FILLER             PIC X(4) VALUE SPACES.
054700                04  PG-1-TOTX          PIC Z(5).
054800                04  FILLER             PIC X(4) VALUE SPACES.
054900                04  PG-1-TOTY          PIC Z(5).
055000                04  FILLER             PIC X(17) VALUE SPACES.
055100            03  FILLER PIC X(68) VALUE '              *  OTHER INCLUDES D
055200-               'UAL STUDENT & CHECK PILOT                '.
055300        02  PAGE-1 REDEFINES PAGE-1-02 OCCURS 23 TIMES PIC X(68).
055400 01     PAGE-2-01.
055500        02  PAGE-2-02.
055600            03  FILLER PIC X(120) VALUE 'FLIGHT CONDITIONS -
055700-               '
055800-             '                                         '.
055900            03  FILLER PIC X(120) VALUE '     TOTAL NUMBER OF ACCIDEN
056000-               'TS WHICH OCCURRED DURING THE FOLLOWING FIVE  MAJOR P
056100-             'HASES OF OPERATION /                     '.
056200            03  FILLER PIC X(120) VALUE '           NUMBER OF ACCIDENT
056300-               'S WITH AT LEAST ONE FATALITY WHICH OCCURRED DURING T
056400-             'HE MAJOR PHASE                           '.
056500            03  PAGE-2-03A.
056600                04  FILLER             PIC X(28) VALUE '
056700-                   'TAKEOFF - - '.
056800                04  PG-2-TO            PIC Z(5).
056900                04  FILLER             PIC X(3) VALUE ' / '.
057000                04  PG-2-TOFAT         PIC Z(5).
057100                04  FILLER             PIC X(79) VALUE SPACES.
057200            03  PAGE-2-03B.
057300                04  FILLER             PIC X(28) VALUE '
057400-                   'IN FLIGHT - '.
057500                04  PG-2-IF            PIC Z(5).
057600                04  FILLER             PIC X(3) VALUE ' / '.
057700                04  PG-2-IFFAT         PIC Z(5).
057800                04  FILLER             PIC X(79) VALUE SPACES.
057900            03  PAGE-2-03C.
058000                04  FILLER             PIC X(28) VALUE '
058100-                   'LANDING - - '.
058200                04  PG-2-LDG           PIC Z(5).
058300                04  FILLER             PIC X(3) VALUE ' / '.
058400                04  PG-2-LDGFAT        PIC Z(5).
058500                04  FILLER             PIC X(79) VALUE SPACES.
058600            03  PAGE-2-03CB.
058700                04  FILLER             PIC X(28) VALUE '
058800-                   'OTHER - - - '.
058900                04  PG-2-OTHER         PIC Z(5).
059000                04  FILLER             PIC X(3) VALUE ' / '.
059100                04  PG-2-OTHERFAT      PIC Z(5).
059200                04  FILLER             PIC X(79) VALUE SPACES.
059300            03  PAGE-2-03CC.
059400                04  FILLER             PIC X(28) VALUE '
059500-                   'NOT REPORTED'.
059600                04  PG-2-NR            PIC Z(5).
059700                04  FILLER             PIC X(3) VALUE ' / '.
059800                04  PG-2-NRFAT         PIC Z(5).
059900                04  FILLER             PIC X(79) VALUE SPACES.
060000            03  FILLER PIC X(120) VALUE '      NINE (9) MOST FREQUENT
060100-               'MINOR PHASES OF OPERATION WITHIN THE FIRST THREE MAJ
060200-             'OR PHASES ABOVE                          '.
060300            03  FILLER PIC X(120) VALUE '           LISTED IN DESCENDI
060400-             'NG ORDER OF FREQUENCY                    '.
060500            03  FILLER PIC X(120) VALUE '
060600-               '       MINOR PHASE OF OPERATION                    TO
060700-             'TAL NO.    ********* INJURIES ********** '
060800            03  FILLER PIC X(120) VALUE '
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-               '                                                       OF
-          'ACCIDENTS  FATAL  SERIOUS  MINOR   NONE '.
           03  PAGE-2-03D OCCURS 9  TIMES.
               04  FILLER                PIC X(7).
               04  MP-NO                 PIC Z9.
               04  PERIOD-04             PIC XX.
               04  MINOR P1              PIC X(68).
               04  FILLER                PIC XX.
               04  TOT-ACC-MP            PIC Z(5).
               04  FILLER                PIC X(5).
               04  FAT-INJ-MP            PIC Z(5).
               04  FILLER                PIC X(3).
               04  SER-INJ-MP            PIC Z(5).
               04  FILLER                PIC X(3).
               04  MIN-INJ-MP            PIC Z(5).
               04  FILLER                PIC X(3).
               04  NON-INJ-MP            PIC Z(5).
           03  FILLER PIC X(120) VALUE '      EIGHT (8) MOST FREQUENT
-              ' TYPES OF ACCIDENTS WITHIN THE FIRST THREE MAJOR PHA
-          'SES ABOVE                                      '.
           03  FILLER PIC X(120) VALUE '            LISTED IN DESCEND
-              'ING ORDER OF FREQUENCY
-          '                                               '.
           03  FILLER PIC X(120) VALUE '
-              '       TYPE OF ACCIDENT                              TO
-          'TAL NO.   ********** INJURIES ********** '.
           03  FILLER PIC X(120) VALUE '
-              '                                                      OF
-          'ACCIDENTS  FATAL  SERIOUS  MINOR   NONE '.
           03  PAGE-2-03DA OCCURS  8 TIMES.
               04  FILLER                     PIC X(7).
               04  TYP-NO                     PIC Z9.
               04  PERIODT-04                 PIC XX.
               04  TYP-DESC                   PIC X(68).
               04  FILLER                     PIC XX.
               04  TOT-ACC-TYP                PIC Z(5).
               04  FILLER                     PIC X(5).
               04  FAT-INJ-TYP                PIC Z(5).
               04  FILLER                     PIC XXX.
               04  SER-INJ-TYP                PIC Z(5).
               04  FILLER                     PIC XXX.
               04  MIN-INJ-TYP                PIC Z(5).
               04  FILLER                     PIC XXX.
               04  NON-INJ-TYP                PIC Z(5).
           03  FILLER PIC X(120) VALUE ' NOTE -- OTHER IS SUM OF ALL
-              ' ACCEPTABLE PHASES AND TYPES EXCEPT THOSE LISTED
-              '                                           '.
       02  PAGE-2 REDEFINES PAGE-2-02 OCCURS 34 TIMES PIC X(120).
 01    PAGE-3-01.
       02  PAGE-3-02.
           03  FILLER PIC X(120) VALUE 'IMPACT CONDITIONS
-              '
-          '                                               '.
           03  PAGE-3-03E.
               04  FILLER PIC X(60) VALUE '     TOTAL NUMBER OF ACCI
-                  'DENTS WHICH RECORD IMPACT ANGLES - '.
               04  TOT-IMPACT        PIC Z(5).
               04  FILLER            PIC X(55) VALUE SPACES.
           03  FILLER PIC X(120) VALUE '      IMPACT ANGLE NUMERICAL
-              'SUMMARY -
-          '                                               '.
           03  FILLER PIC X(120) VALUE '            AVERAGE ANGLE
-              '                  IMPACT ANGLE CATEGORIES - DEGREES
-          '                                               '.
           03  FILLER PIC X(120) VALUE '                 DEGREES
-              '
-          '                                               '.
           03  FILLER PIC X(120) VALUE '
-              ' 0 -15       16-30       31-45       46-60      61-75      7
-          '6-90          90+                          '.
           03  PAGE-3-03F.
               04  FILLER            PIC X(13) VALUE SPACES.
               04  AVG-ANGLE-3       PIC Z(5).
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[illegible]                04  FILLER          PIC X(11) VALUE SPACES.
[illegible]                04  F0-15           PIC Z(5).
068100                     04  FILLER          PIC X(5) VALUE SPACES.
068200                     04  F16-30          PIC Z(5).
068300                     04  FILLER          PIC X(5) VALUE SPACES.
068400                     04  F31-45          PIC Z(5).
068500                     04  FILLER          PIC X(5) VALUE SPACES.
068600                     04  F46-60          PIC Z(5).
068700                     04  FILLER          PIC X(5) VALUE SPACES.
068800                     04  F61-75          PIC Z(5).
068900                     04  FILLER          PIC X(5) VALUE SPACES.
069000                     04  F76-90          PIC Z(5).
069100                     04  FILLER          PIC X(5)  VALUE SPACES.
069200                     04  F90        PIC Z(5).
069300                     04  FILLER     PIC X(26) VALUE SPACES.
069400                 03  PAGE-3-03G.
069500                     04  FILLER PIC X(73) VALUE '    TOTAL NUMBER OF ACCI
069600-                        'DENTS WHICH RECORD IMPACT VELOCITY -  '.
069700                     04  VEL-IMP         PIC Z(5).
069800                     04  FILLER          PIC X(42) VALUE SPACES.
069900                 03  FILLER PIC X(120) VALUE '     IMPACT VELOCITY NUMERIC
070000-                    'AL SUMMARY -
070100-                '                                              '.
070200                 03  FILLER PIC X(120) VALUE '            AVERAGE VELOCITY
070300-                    '        IMPACT VELOCITY CATEGORIES - KNOTS
070400-                '                                              '.
070500                 03  FILLER PIC X(120) VALUE '                 KNOTS
070600-                    '
070700-                '                                              '.
070800                 03  FILLER PIC X(120) VALUE '
070900-                    ' 1-30       31-60      61-90      91-120       120+
071000-                '                                              '.
071100                 03  PAGE-3-03H.
071200                     04  FILLER PIC X(65) VALUE '     TOTAL NUMBER OF ACCI
071300-                        'DENTS WHICH RECORD STOPPING DISTANCES - '.
071400                     04  STOP-DIST       PIC Z(5).
071500                     04  FILLER          PIC X(50) VALUE SPACES.
071600                 03  FILLER PIC X(120) VALUE '      STOPPING DISTANCE NUMER
071700-                    'ICAL SUMMARY -
071800-                '                                              '.
071900                 03  FILLER PIC X(120) VALUE '            AVERAGE STOPPING
072000-                    '                 STOPPING DISTANCE CATEGORIES - FEET
072100-                '                                              '.
072200                 03  FILLER PIC X(120) VALUE '            DISTANCE - FEET
072300-                    '
072400-                '                                              '.
072500                 03  FILLER PIC X(120) VALUE '
072600-                    ' 1 -59     60-119    120-179    180-239    240-299    300
072700-                '-359        360+                               '.
072800                 03  FILLER PIC X(120) VALUE '      OCCUPANT INJURY NUMERIC
072900-                    'AL SUMMARY AT RESPECTIVE AIRCRAFT DAMAGE SEVERITY IN
073000-                'DICES -                                       '.
073100                 03  FILLER PIC X(120) VALUE '            DAMAGE SEVERITY
073200-                    '          * * * *   OCCUPANT   INJURY    * * * *
073300-                '                                              '.
073400                 03  FILLER PIC X(120) VALUE '
073500-                    '          FATAL     SERIOUS     MINOR      NONE
073600-                '                                              '.
073700                 03  PAGE-3-03I OCCURS 5 TIMES.
073800                     04  FILLER          PIC X(12).
073900                     04  SEV-NAME        PIC X(8).
074000                     04  FILLER          PIC X(16).
074100                     04  SEV-FAT         PIC Z(5).
074200                     04  FILLER          PIC X(5).
074300                     04  SEV-SER         PIC Z(5).
074400                     04  FILLER          PIC X(5).
074500                     04  SEV-MIN         PIC Z(5).
074600                     04  FILLER          PIC X(5).
074700                     04  SEV-NON         PIC Z(5).
074800                     04  FILLER          PIC X(49).
074900             02  PAGE-3 REDEFINES PAGE-3-02 OCCURS 25 TIMES PIC X(120).
075000             02  PAGE-4-02.
075100                 03  FILLER PIC X(91)  VALUE 'AIRCRAFT CABIN ACCOMMODATION
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-              'S -
-              '                   '.
           03  PAGE-4-03A.
               04  FILLER PIC X(63) VALUE '      NUMBER OF ACCIDENTS
-                  'IN WHICH SEAT FAILURE OCCURRED  - - - '.
               04  SEAT-FAIL-ACC    PIC Z(5).
               04  FILLER           PIC X(23) VALUE SPACES.
           03  PAGE-4-03B.
               04  FILLER PIC X(63) VALUE '      TOTAL NUMBER OF SEAT
-                  ' FAILURES - - - - - - - - - - - - - - - '.
               04  SEAT-FAIL        PIC Z(5).
               04  FILLER           PIC X(23) VALUE SPACES.
           03  PAGE-4-03C.
               04  FILLER PIC X(63) VALUE '      NUMBER OF ACCIDENTS
-                  'IN WHICH SEAT BELT FAILURE OCCURRED - '.
               04  SEAT-BELT-ACC    PIC Z(5).
               04  FILLER           PIC X(23) VALUE SPACES.
           03  PAGE-4-03D.
               04  FILLER PIC X(63) VALUE '      TOTAL NUMBER OF SEAT
-                  ' BELT FAILURES  - - - - - - - - - - - - '.
               04  SEAT-BELT-FAIL   PIC Z(5).
               04  FILLER           PIC X(23) VALUE SPACES.
           03  PAGE-4-03E.
               04  FILLER PIC X(63) VALUE '    * NUMBER OF SHOULDER H
-                  'ARNESS USED - - - - - - - - - - - - - '.
               04  SH-HARN-USED     PIC Z(5).
               04  FILLER           PIC X(23) VALUE SPACES.
           03  PAGE-4-03F.
               04  FILLER PIC X(63) VALUE '    * NUMBER OF SHOULDER H
-                  'ARNESS FAILURES - - - - - - - - - - - '.
               04  SH-HARN-FAIL     PIC Z(5).
               04  FILLER           PIC X(23) VALUE SPACES.
           03  PAGE-4-03G.
               04  FILLER PIC X(63) VALUE '    * NUMBER OF CRASH HELM
-                  'ETS USED / NOT USED - - - - - - - - - '.
               04  CRASH-HEL-USED   PIC Z(5).
               04  FILLER     PIC X(3) VALUE ' / '.
               04  CRASH-HEL-UNUSED     PIC Z(5).
               04  FILLER           PIC X(15) VALUE SPACES.
           03  FILLER PIC X(91) VALUE '          *  APPLICABLE TO AGRIC
-              'ULTURAL AIRCRAFT ONLY
-              '                   '.
           03  FILLER PIC X(91) VALUE 'IMPACT AREA
-              '
-              '                   '.
           03  FILLER PIC X(91) VALUE '       PERCENT OF ACCIDENTS WHI
-              'CH OCCURRED IN PARTICULAR TERRAIN TYPE
-              '                   '.
           03  FILLER PIC X(91) VALUE '
-              'TERRAIN TYPE
-              '                   '.
           03  FILLER PIC X(91) VALUE '
-              '                                                      PER
-              'CENT        '.
           03  FILLER PIC X(91) VALUE '
-              '                                                      ACC
-              'IDENT       '.
           03  FILLER PIC X(91) VALUE '
-              '                                                     OCCU
-              'RRENCE (1)'.
           03  PAGE-4-03GROUP.
           04  PAGE-4-03H OCCURS 13 TIMES.
               05  TERR-TYP         PIC X(68).
               05  FILLER           PIC X(10).
               05  PCT-TER          PIC Z(5).
               05  FILLER-4-03H     PIC X(8).
           03  FILLER PIC X(91) VALUE '          (1)  PERCENT IS RATI
-              'O OF PARTICULAR TERRAIN TO NUMBER OF ACCIDENTS SCREE
-              'NED         '.
       02  PAGE-4 REDEFINES PAGE-4-02 OCCURS 29 TIMES PIC X(91).
       02  PAGE-5-02.
           03  FILLER PIC X(110) VALUE 'CAUSE / FACTOR SUMMARY
-              '
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                                                      '.
              03  FILLER PIC X(110) VALUE '
                  '                CAUSE
                  '      FATAL           NONFATAL     '.
              03  FILLER PIC X(110) VALUE '
                  '
                  '    ACCIDENTS      ACCIDENTS      '.
              03  PAGE-5-02A.
                  04  FILLER PIC X(5) VALUE SPACES.
                  04  CF-NO   PIC X.
                  04  FILLER PIC XX VALUE '. '.
                  04  CAUSE-FACTOR-5   PIC X(68).
                  04  FILLER           PIC X(7)  VALUE SPACES.
                  04  FILLER           PIC X(3) VALUE SPACES.
                  04  CF-FATALS        PIC Z(5).
                  04  FILLER           PIC X(10) VALUE SPACES.
                  04  CF-NONFAT        PIC Z(5).
                  04  FILLER           PIC X(12) VALUE SPACES.
              03  FILLER PIC X(110) VALUE '* * PILOT * *
                  '
                  '                                   '.
              03  FILLER PIC X(110) VALUE '* * COPILOT * *
                  '
                  '                                   '.
              03  FILLER PIC X(110) VALUE '* * DUAL STUDENT * *
                  '
                  '                                   '.
              03  FILLER PIC X(110) VALUE '* * CHECK PILOT * *
                  '
                  '                                   '.
              03  FILLER PIC X(110) VALUE '* * AIRFRAME * *
                  '
                  '                                   '.
              03  FILLER PIC X(110) VALUE '* * MISCELLANEOUS ACTS, COND
                  'ITIONS * *
                  '                                   '.
          02  PAGE-5 REDEFINES PAGE-5-02 OCCURS 10 TIMES PIC X(110).
       01 P-IND-REC-01.
          02  P-IND-02.
              03  P-IND-DESC  PIC X(48).
              03  P-IND-ENG   PIC X(68).
       01 GTOT-OP-01.
          02  GTOT-OP-02.
              03  GTOT-OP-03 OCCURS 43 TIMES.
                  04  GTOT-OP OCCURS 5 TIMES PIC 9(5).
       01 GTOT-TYP-01.
          02  GTOT-TYP-02.
              03  GTOT-TYP-03 CCCURS 23 TIMES.
                  04  GTOT-TYP OCCURS 5 TIMES PIC 9(5).
       01 G-CAUSE-01.
          02  G-CAUSE OCCURS 487 TIMES PIC 9(5).
       01 G-CAUSE-FAT-01.
          02  G-CAUSE-FAT OCCURS 487 TIMES PIC 9(5).
       01 G-CAUSE-NONFAT-01.
          02  G-CAUSE-NONFAT OCCURS 487 TIMES PIC 9(5).
       01 OP-PH-01.
          02  OP-PH-CODE.
              03  FILLER PIC X(22) VALUE 'C0C1C2C3C4C5C6DADBDDDE'.
              03  FILLER PIC X(22) VALUE 'DFDGDHDIDJDKDLDMDNDODI'.
              03  FILLER PIC X(22) VALUE 'D2D3D4D5D6D7D8D9EAEBEC'.
              03  FILLER PIC X(22) VALUE 'EDEEEFEGEHEIEJEKZ     '.
          02  OP-PH REDEFINES OP-PH-CODE OCCURS 42 TIMES PIC XX.
       01 CAUSE-FACTOR-01.
          02  CAUSE-FACTOR-02.
              03 FILLER PIC X(28) VALUE '6401640264036404640564066407'.
              03 FILLER PIC X(28) VALUE '6408640964106411641264136414'.
              03 FILLER PIC X(28) VALUE '6415641664176418641964206421'.
              03 FILLER PIC X(28) VALUE '6422642364246425642664276428'.
              03 FILLER PIC X(28) VALUE '6429643064316432643364346435'.
              03 FILLER PIC X(28) VALUE '6436643764386439644064426443'.
              03 FILLER PIC X(28) VALUE '6444644564466447644864496450'.
              03 FILLER PIC X(28) VALUE '6451645264536454645564566462'.
              03 FILLER PIC X(28) VALUE '6464646564666467647164746479'.
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                 03 FILLER PIC X(28) VALUE '6480648164826501650265036504'.
                 03 FILLER PIC X(28) VALUE '6505650665076508650965106511'.
                 03 FILLER PIC X(28) VALUE '6512651365146515651665176518'.
                 03 FILLER PIC X(28) VALUE '6519652065216522652365246525'.
                 03 FILLER PIC X(28) VALUE '6526652765286529653065316532'.
                 03 FILLER PIC X(28) VALUE '6533653465356536653765386539'.
                 03 FILLER PIC X(28) VALUE '6540654265436544654565466547'.
                 03 FILLER PIC X(28) VALUE '6548654965506551655265536554'.
                 03 FILLER PIC X(28) VALUE '6555655665626564656565666567'.
                 03 FILLER PIC X(28) VALUE '6571657465796580658165826601'.
                 03 FILLER PIC X(28) VALUE '6602660366046605660666076608'.
                 03 FILLER PIC X(28) VALUE '6609661066116612661366146615'.
                 03 FILLER PIC X(28) VALUE '6616661766186619662066216622'.
                 03 FILLER PIC X(28) VALUE '6623662466256626662766286629'.
                 03 FILLER PIC X(28) VALUE '6630663166326633663466356636'.
                 03 FILLER PIC X(28) VALUE '6637663866396640664266436644'.
                 03 FILLER PIC X(28) VALUE '6645664666476648664966506651'.
                 03 FILLER PIC X(28) VALUE '6652665366546655665666626664'.
                 03 FILLER PIC X(28) VALUE '6665666666676671667466796680'.
                 03 FILLER PIC X(28) VALUE '6681668367016702670367046705'.
                 03 FILLER PIC X(28) VALUE '6706670767086709671067116712'.
                 03 FILLER PIC X(28) VALUE '6713671467156716671767186719'.
                 03 FILLER PIC X(28) VALUE '6720672167226723672467256726'.
                 03 FILLER PIC X(28) VALUE '6727672867296730673167326733'.
                 03 FILLER PIC X(28) VALUE '6734673567366737673867396740'.
                 03 FILLER PIC X(28) VALUE '6742674367446745674667476748'.
                 03 FILLER PIC X(28) VALUE '6749675067516752675367546755'.
                 03 FILLER PIC X(28) VALUE '6756676267646765676667676771'.
                 03 FILLER PIC X(28) VALUE '6774677967806781678270AA70AB'.
                 03 FILLER PIC X(28) VALUE '70AC70AD70AE70AF70AG70AH70AJ'.
                 03 FILLER PIC X(28) VALUE '70AY70BA70BB70BC70BD70BE70BF'.
                 03 FILLER PIC X(28) VALUE '70BG70BH70BI70BJ70BY70CA70CB'.
                 03 FILLER PIC X(28) VALUE '70CC70CD70CE70CF70CG70CH70CI'.
                 03 FILLER PIC X(28) VALUE '70CJ70CK70CL70CM70CN70CP70CY'.
                 03 FILLER PIC X(28) VALUE '70D070D170D270D370D470D570D6'.
                 03 FILLER PIC X(28) VALUE '70D988AB88AC88AD88AE88AE88AE'.
                 03 FILLER PIC X(28) VALUE '88AF88AG88AH88AI88AJ88AK88AL'.
                 03 FILLER PIC X(28) VALUE '88AM88AN88AP88AQ88AR88AS88AT'.
                 03 FILLER PIC X(28) VALUE '88AU88AV88AW88AX88AZ88BA88BB'.
                 03 FILLER PIC X(28) VALUE '88BC88BD88BE88BF88BG88BH88BI'.
                 03 FILLER PIC X(28) VALUE '88BJ88BK88BL88BM88BN88BO88BP'.
                 03 FILLER PIC X(28) VALUE '88BQ88BR88BS88BT88BU88BV88BW'.
                 03 FILLER PIC X(28) VALUE '88BX88BY88BZ88CB88CD88CE88CF'.
                 03 FILLER PIC X(28) VALUE '88CG88CH88CI88CJ88CK88CL88CM'.
                 03 FILLER PIC X(28) VALUE '88CN88CO88CP88CQ88CR88CS88CT'.
                 03 FILLER PIC X(28) VALUE '88CU88CV88CW88CX88CY88CZ88DA'.
                 03 FILLER PIC X(28) VALUE '88DB88DC88DD88DE88DF88DG8801'.
                 03 FILLER PIC X(28) VALUE '8802880388048805880688078808'.
                 03 FILLER PIC X(28) VALUE '8809881088118812881388148815'.
                 03 FILLER PIC X(28) VALUE '8816881788188819882088218822'.
                 03 FILLER PIC X(28) VALUE '8823882488258826882788288829'.
                 03 FILLER PIC X(28) VALUE '8830883188328833883488358836'.
                 03 FILLER PIC X(28) VALUE '8837883888398840884188428843'.
                 03 FILLER PIC X(28) VALUE '8844884588468847884888498850'.
                 03 FILLER PIC X(28) VALUE '8851885288538854885588568860'.
                 03 FILLER PIC X(28) VALUE '8861886288638864886588668867'.
                 03 FILLER PIC X(28) VALUE '8868886988708871887288738874'.
                 03 FILLER PIC X(28) VALUE '8875887688778878887988808881'.
                 03 FILLER PIC X(28) VALUE '8882888388848885888688878888'.
                 03 FILLER PIC X(28) VALUE '8889889088918892889388948895'.
                 03 FILLER PIC X(28) VALUE '8896889788988899            '.
             02  CAUSE-FACTOR-02R REDEFINES CAUSE-FACTOR-02
                 OCCURS 500 TIMES PIC X(4).
         01  SAVE-SUB-01.
             02  SAVE-SUB OCCURS 16 TIMES PIC 99.
         01  G-PG-1-01.
             02  G-PG-1-02 OCCURS 4 TIMES.
                 03  G-PG-1 OCCURS 4 TIMES PIC 9(5).
         01  PG-1-SERIOUS-01.
             02  PG-1-SER-02 OCCURS 4 TIMES.
                 03  PG-1-SER OCCURS 4 TIMES PIC 9(5).
         01  HOLD-ARRAY-01.
             02  HOLD-ARRAY OCCURS 6 TIMES PIC X(3).
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097100 01  C-SAVE-01.
097200     02  C-SAVE-02 OCCURS 4 TIMES PIC 9(3).
097300 01  CAUSE-FACTOR-HOLD.
097400     02  FACTOR-02          PIC XX.
097500     02  CAUSE-02           PIC XX.
097600 01  GTERRAIN-01.
097700     02  GTERRAIN-COUNT OCCURS 13 TIMES PIC 9(4).
097800 01  G-SERIOUS.
097900     02  GSER    OCCURS 5 TIMES INDEXED BY GS-INDEX.
098000         03  GS    OCCURS 4 TIMES INDEXED BY  GSERIOUS-INDEX
098100                                                         PIC 9(5).
098200 01  F0808-01.
098300     02  F0808-A                  PIC X(12).
098400     02  FILLER             PIC X(6).
098500 01  PAGE-4-WORK.
098600     02  PAGE-4-W02  OCCURS 13 TIMES PIC X(91).
098700 PROCEDURE DIVISION.
098800     OPEN INPUT NTSB, HEAD
098900          OUTPUT PRT.
099000     MOVE SPACES TO FILL-ER.
099100     MOVE SEVERITY-77 TO SEVERITY.
099200     MOVE TERRAIN-77 TO TERRAIN-01.
099300     MOVE TYPES-77 TO TYPES-01.
099400     MOVE ZERO TO G-PG-1-01.
099500     MOVE ZERO TO GTERRAIN-01.
099600     MOVE ZERO TO GTOT-OP-01 G-SERIOUS G-CAUSE-FAT-01.
099700     MOVE ZERO TO G-CAUSE-01 GTOT-TYP-01 G-SERIOUS G-PG-1-01.
099800     MOVE ZERO TO G-CAUSE-NONFAT-01.
099900     MOVE SPACES TO P-WORK.
099910*
099920******** PLACE PERCENT SYMBOL IN ITS FIELD
099930*
100000 MOVE-PCT.
100100     ADD 1 TO I.
100200     IF I GREATER THAN 13 MOVE ZERO TO I
100300         GO TO READ-NTSB ELSE
100400         MOVE PERCNT TO FILLER-4-03H (I)
100500         GO TO MOVE-PCT.
100600 READ-NTSB.
100700     READ NTSB INTO NTSB-WORK AT END
100800         CLOSE NTSB WITH LOCK
100900         PERFORM PRINT-SUMMARY THRU END-PAGE-5
101000         PERFORM INITIALIZE-COUNTERS THRU END-INITIALIZE
101100         GO TO EOJ.
101200*
101300******** INITIALIZE COUNTERS AND FLAGS
101400*
101500 CHECK-HOLD.
101600     IF NOT (F012 = HOLD-MAKE AND F013 = HOLD-MODEL)
101700         ADD 1 TO SUMMARY-COUNTER
101800         IF SUMMARY-COUNTER GREATER THAN 1
101900             PERFORM PRINT-SUMMARY THRU END-PAGE-5.
102000     IF NOT(F012 = HOLD-MAKE AND F013 = HOLD-MODEL)
102200         PERFORM INITIALIZE-COUNTERS THRU END-INITIALIZE
102300         MOVE F006 TO HOLD-MAKE-NAME
102400         MOVE F012 TO HOLD-MAKE
102500         MOVE F013 TO HOLD-MODEL.
102700     MOVE 1 TO D.
102800     ADD 1 TO GTOT-AC.
102900     ADD 1 TO TOT-AC.
103000*
103100********  SEARCH TYPE OF ACCIDENT IN MAJOR FIELD BUT REJECT THOSE
103200********  FOR WHICH A MATCH IS FOUND.
103300*
103400 SEARCH-TYPES.
103500     ADD 1 TO J.
103600     IF J GREATER THAN 12
103700         MOVE ZERO TO J
103800         MOVE '0' TO ADD-TOT-AC
103900         GO TO TOTAL-AC.
104000     IF TYYP  (J) = F02801
104200         MOVE ZERO TO J
104300         MOVE '1' TO ADD-TOT-AC
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104400                GO TO READ-NTSB.
104500         GO TO SEARCH-TYPES.
104600 TOTAL-AC.
104700*
104800******* ACCUMULATE TOTAL FATALITIES, SERIOUS, MINOR & NONE
104900*
105000*             SKIP ALL Z CODES IN TOTAL ON BOARD AREA
105100*
105200         IF F02901 = 'C'
105300             ADD 1 TO GTOT-T-O
105400             ADD 1 TO TOT-T-O
105500             IF F079 = 'F' ADD 1 TO FAT-TO
105600                 ADD 1 TO GFAT-TO.
105700         IF F02901 = 'D'
105800             ADD 1 TO GTOT-FLY
105900             ADD 1 TO TOT-FLY
106000             IF F079 = 'F' ADD 1 TO FAT-INFLT
106100                 ADD 1 TO GFAT-INFLT.
106200         IF F02901 = 'E'
106300             ADD 1 TO GTOT-LDG
106400             ADD 1 TO TOT-LDG
106500             IF F079 = 'F' ADD 1 TO FAT-LOG
106600                 ADD 1 TO GFAT-LDG.
106700         IF F02901 = 'A' OR 'B'
106800             ADD 1 TO GTOT-TS
106900             ADD 1 TO TOT-TS
107000             IF F079 = 'F' ADD 1 TO FAT-TS
107100                           ADD 1 TO GFAT-TS.
107200         IF F02901 = 'Z' OR ' '
107300             ADD 1 TO GTOT-NR
107400             ADD 1 TO TOT-NR
107500             IF F079 = 'F' ADD 1 TO FAT-NR
107600                           ADD 1 TO GFAT-NR.
107610*
107620******** CHECK OPERATIONAL PHASES - TAKE-OFF, IN FLIGHT & LANDING
107630*
107700         IF NOT (F02901 = 'C' OR 'D' OR 'E')
107800             GO TO READ-NTSB.
107900         ADD 1 TO TOT-AC-TYPE.
108000         ADD 1 TO GTOT-AC-TYPE.
108100         TRANSFORM F0808 (3) FROM SPACES TO ZEROS.
108200         MOVE F08001018 (3,1,6) TO REC-TOT-OCC.
108300         ADD REC-TOT-OCC TO TOT-OCC.
108400         ADD REC-TOT-OCC TO GTOT-OCC.
108500         IF TOT-AC-TYPE  NOT = ZERO
108600         DIVIDE TOT-OCC BY TOT-AC-TYPE GIVING  AV-OCC ROUNDED.
108700         IF GTOT-AC-TYPE NOT = ZERO
108800         DIVIDE GTOT-OCC BY GTOT-AC-TYPE GIVING GAVG-OCC ROUNDED.
108900*
109000**** TALLY THE HIGHEST SEVERITY LEVEL RECORDED FOR THE ACCIDENT.
109100**** FOR PAGE 1 SUMMARY USING TOTAL ON BOARD FIELD
109200*
109300         MOVE F08001018 (3,1,1) TO NTSBXY1.
109400         MOVE F08001018 (3,1,2) TO NTSBXY2.
109500         MOVE F08001018 (3,1,3) TO NTSBXY3.
109600         MOVE F08001018 (3,1,4) TO NTSBXY4.
109700         IF  F079 = 'F'
109800             ADD 1 TO GTOT-FAT
109900             ADD 1 TO TOT-FAT.
110000         IF NTSBXY1               IS = ZEROS AND
110100            NTSBXY2               IS NOT = ZEROS
110200             ADD 1 TO GTOT-SER
110300                ADD 1 TO TOT-SER.
110400         IF NTSBXY1               IS = ZEROS AND
110500            NTSBXY2               IS = ZEROS AND
110600            NTSBXY3               IS NOT = ZEROS
110700             ADD 1 TO GTOT-MNR
110800                ADD 1 TO TOT-MNR.
110900         IF NTSBXY1               IS = ZEROS AND
111000            NTSBXY2               = ZERO AND
111100            NTSBXY3               = ZERO AND
111200            NTSBXY4               IS NOT = ZEROS
111300             ADD 1 TO GTOT-NON
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111400           ADD 1 TO TOT-NON.
111500*
111600******** ACCUMULATE INJURIES INTO PILOT, COPILOT, PASSENGERS AND
111700******** OTHERS.  OTHERS TO INCLUDE DUAL STUDENT AND CHECK PILOT.
111800*
111900     MOVE 1 TO SER-SUB.
112000 ACCUMULATE-PG-1.
112100     IF SER-SUB = 5 MOVE 4 TO S-SUB
112200         ELSE MOVE SER-SUB TO S-SUB.
112300     IF SER-SUB = 1 MOVE F08001A (1)      TO HOLD-ARRAY-01.
112400     IF SER-SUB = 2 MOVE F08001A (2)      TO HOLD-ARRAY-01.
112500     IF SER-SUB = 3 MOVE F08001B (2,3)    TO HOLD-ARRAY-01.
112600     IF SER-SUB = 4 MOVE F08001A (3)      TO HOLD-ARRAY-01.
112700     IF SER-SUB = 5 MOVE F08001B (1,1)    TO HOLD-ARRAY-01.
112800     MOVE HOLD-ARRAY (1) TO NTSBXY1.
112900     MOVE HOLD-ARRAY (2) TO NTSBXY2.
113000     MOVE HOLD-ARRAY (3) TO NTSBXY3.
113100     MOVE HOLD-ARRAY (4) TO NTSBXY4.
113200     ADD NTSBXY1 TO PG-1-SER (S-SUB, 1).
113300     ADD NTSBXY2 TO PG-1-SER (S-SUB, 2).
113400     ADD NTSBXY3 TO PG-1-SER (S-SUB, 3).
113500     ADD NTSBXY4 TO PG-1-SER (S-SUB, 4).
113600     ADD NTSBXY1 TO G-PG-1   (S-SUB, 1).
113700     ADD NTSBXY2 TO G-PG-1   (S-SUB, 2).
113800     ADD NTSBXY3 TO G-PG-1   (S-SUB, 3).
113900     ADD NTSBXY4 TO G-PG-1   (S-SUB, 4).
114000     ADD 1 TO SER-SUB.
114100     IF SER-SUB GREATER THAN 5 NEXT SENTENCE
114200         ELSE GO TO ACCUMULATE-PG-1.
114300*
114400******** CHECK FOR PRESENCE OF IMPACT ANGLE, IMPACT VELOCITY,
114500******** STOPPING DISTANCE, SEAT FAILURE, SEAT BELT FAILURE OR ATT
114600******** AT IMPACT.
114700*
114800 PRINT-CRITERIA.
114900     IF F13302 = SPACES NEXT SENTENCE ELSE
115000         EXAMINE F13302 TALLYING ALL 'Z'
115100         IF TALLY = ZERO GO TO FORM-RECORD.
115200     MOVE ZERO TO TALLY.
115300     IF F136 = SPACES NEXT SENTENCE ELSE
115400         EXAMINE F136 TALLYING ALL 'Z'
115500         IF TALLY = ZERO GO TO FORM-RECORD.
115600     MOVE ZERO TO TALLY.
115700     IF F152 = SPACES NEXT SENTENCE ELSE
115800         EXAMINE F152 TALLYING ALL 'Z'
115900         IF TALLY = ZERO GO TO FORM-RECORD.
116000     MOVE ZERO TO TALLY.
116100     IF F139 = SPACES NEXT SENTENCE ELSE
116200         EXAMINE F139 TALLYING ALL 'Z'
116300         IF TALLY = ZERO GO TO FORM-RECORD.
116400     MOVE ZERO TO TALLY.
116500     IF F140 = SPACES NEXT SENTENCE ELSE
116600         EXAMINE F140 TALLYING ALL 'Z'
116700         IF TALLY = ZERO GO TO FORM-RECORD.
116800     MOVE ZERO TO TALLY.
116900     IF F151  = SPACES NEXT SENTENCE ELSE
117000         EXAMINE F151 TALLYING ALL 'Z'
117100         IF TALLY NOT = 3 MOVE ZERO TO TALLY
117200         GO TO FORM-RECORD.
117300     MOVE ZERO TO TALLY.
117400     GO TO CABIN-INJURY.
117500 FORM-RECORD.
117600     MOVE '0' TO READER-SWITCH.
117700     IF ADD-TOT-AC = '1'
117800         MOVE '0' TO ADD-TOT-AC
117900         ADD 1 TO GTOT-AC
118000         ADD 1 TO TOT-AC.
118100     WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 0.
118200     WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 3.
118300*
118400******** CHECK DATE OF ACCIDENT
118500     MOVE SPACES TO P-WORK.
118600*
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118700     IF F004 = SPACES OR F00401 = 'Z' NEXT SENTENCE ELSE
118800          MOVE F004 TO DATE-HOLD-01A
118900          MOVE DA TO DA-B
119000     MOVE MO TO MO-B
119100          MOVE YR TO YR-B
119200          MOVE DATE-HOLD-01B TO FDATA
119300          PERFORM MOVE-DIRECT.
119400     ADD 1 TO D.
119500*
119600******** CHECK AIRCRAFT MAKE
119700*
119800     IF F006 = SPACES NEXT SENTENCE ELSE
119900          MOVE F006 TO FDATA
120000          PERFORM MOVE-DIRECT.
120100     ADD 1 TO D.
120200*
120300******** CHECK AIRCRAFT MODEL
120400*
120500     IF F007 = SPACES NEXT SENTENCE ELSE
120600          MOVE F007 TO FDATA
120700     PERFORM MOVE-DIRECT.
120800     ADD 1 TO D.
120900     WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
121000*
121100******** CHECK AIRCRAFT DAMAGE
121200*
121300     IF F021 = SPACES OR 'Z' NEXT SENTENCE ELSE
121400          MOVE SPACES TO HD-KEY
121500          MOVE 013434 TO CCC
121600          MOVE F021 TO CHAR1
121700          PERFORM READER THRU REXIT.
121800     ADD 1 TO D.
121900*
122000******** FIRE AFTER IMPACT
122100*
122200     IF F022 = SPACES OR 'Z' NEXT SENTENCE ELSE
122300          MOVE SPACES TO HD-KEY
122400          MOVE 013535 TO CCC
122500          MOVE F022 TO CHAR1
122600          PERFORM READER THRU REXIT.
122700     ADD 1 TO D.
122800*
122900******** KIND OF FLYING
123000*
123100     IF F025 = SPACES OR 'CZ' OR 'DZ' NEXT SENTENCE ELSE
123200          MOVE SPACES TO HD-KEY
123300          MOVE 013940 TO CCC
123400          MOVE F025 TO CODE2
123500          PERFORM READER THRU REXIT.
123600     ADD 1 TO D.
123700     WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
123800*
123900******** FIRST TYPE OF ACCIDENT
124000*
124100     IF F028 = SPACES OR '7 ' NEXT SENTENCE ELSE
124200          ADD 1 TO HEAD-COUNT
124300          MOVE SPACES TO HD-KEY
124400          MOVE 014447 TO CCC
124500          MOVE F02801 TO CHAR2
124600          PERFORM READER THRU REXIT.
124700     IF F02802 NOT = SPACES
124800          ADD 1 TO HEAD-COUNT
124900          MOVE F02802 TO CHAR1
125000          PERFORM READER THRU REXIT.
125100     ADD 1 TO D.
125200     MOVE ZERO TO HEAD-COUNT.
125300     WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
125400*
125500******** FIRST PHASE OF OPERATION
125600*
125700     IF F029 = SPACES OR 'Z ' NEXT SENTENCE ELSE
125800          ADD 1 TO HEAD-COUNT
125900          MOVE SPACES TO HD-KEY
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126000             MOVE 014851 TO CCC
126100             MOVE F02901 TO CHAR2
126200             PERFORM READER THRU REXIT.
126300         IF F02902 NOT = SPACES
126400             ADD 1 TO HEAD-COUNT
126500             MOVE F02902 TO CHAR1
126600             PERFORM READER THRU REXIT.
126700         ADD 1 TO D.
126800         MOVE ZERO TO HEAD-COUNT.
126900*
127000******** SECONDARY TYPE OF ACCIDENT
127100*
127200         IF F030 = SPACES OR 'Z ' NEXT SENTENCE ELSE
127300             ADD 1 TO HEAD-COUNT
127400             MOVE SPACES TO HD-KEY
127500             MOVE 014447 TO CCC
127600             MOVE F03001 TO CHAR2
127700             PERFORM READER THRU REXIT.
127800         IF F03002 NOT = SPACES
127900             ADD 1 TO HEAD-COUNT
128000             MOVE F03002 TO CHAR1
128100             PERFORM READER THRU REXIT.
128200         ADD 1 TO D.
128300         MOVE ZERO TO HEAD-COUNT.
128400*
128500******** SECONDARY PHASE OF OPERATION
128600*
128700         IF F031 = SPACES OR 'Z ' NEXT SENTENCE ELSE
128800             ADD 1 TO HEAD-COUNT
128900             MOVE SPACES TO HD-KEY
129000             MOVE 014851 TO CCC
129100             MOVE F03101 TO CHAR2
129200             PERFORM READER THRU REXIT.
129300         IF F03102 NOT = SPACES
129400             ADD 1 TO HEAD-COUNT
129500             MOVE F03102 TO CHAR1
129600             PERFORM READER THRU REXIT.
129700         ADD 1 TO D.
129800         MOVE ZERO TO HEAD-COUNT.
129900*
130000******** AIRCRAFT SPEED
130100*
130200         EXAMINE F034 TALLYING ALL 'Z'.
130300         IF F034 = SPACES OR TALLY GREATER THAN ZERO NEXT SENTENCE
130400             ELSE
130500             EXAMINE F034 REPLACING LEADING ZERO BY SPACES
130600             MOVE F034 TO FDATA
130700             PERFORM MOVE-DIRECT.
130800         ADD 1 TO D.
130900         MOVE ZERO TO TALLY.
131000*
131100******** AIRPORT PROXIMITY
131200*
131300         IF F048 = SPACES OR 'Z' NEXT SENTENCE ELSE
131400             MOVE SPACES TO HD-KEY
131500             MOVE 023131 TO CCC
131600             MOVE F048 TO CHAR1
131700             PERFORM READER THRU REXIT.
131800         ADD 1 TO D.
131900*
132000******** RUNWAY COMPOSITION
132100*
132200         IF F054 = SPACES OR 'Z' NEXT SENTENCE ELSE
132300             MOVE SPACES TO HD-KEY
132400             MOVE 026161 TO CCC
132500             MOVE F054 TO CHAR1
132600             PERFORM READER THRU REXIT.
132700         ADD 1 TO D.
132800*
132900******** RUNWAY SURFACE
133000*
133100         IF F055 = SPACES OR 'Z' NEXT SENTENCE ELSE
133200             MOVE SPACES TO HD-KEY
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               MOVE 026262 TO CCC
               MOVE F055 TO CHAR1
               PERFORM READER THRU REXIT.
           ADD 1 TO D.
      *
      ******** RUNWAY HAZARDS
      *
           IF F057 = SPACES OR 'Z' NEXT SENTENCE ELSE
               MOVE SPACES TO HD-KEY
               MOVE 026565 TO CCC
               MOVE F057 TO CHAR1
               PERFORM READER THRU REXIT.
           ADD 1 TO D.
      *
      ******** RUNWAY LENGTH
      *
           EXAMINE F060 TALLYING ALL 'Z'.
           IF F060 = SPACES OR TALLY GREATER THAN ZERO NEXT SENTENCE
               ELSE
               EXAMINE F060 REPLACING LEADING ZERO BY SPACES
               MOVE F060 TO FDATA
               PERFORM MOVE-DIRECT.
           ADD 1 TO D.
           MOVE ZERO TO TALLY.
      *
      ******** TERRAIN TYPE
      *
           IF F065 = SPACES OR 'Z' NEXT SENTENCE ELSE
               MOVE SPACES TO HD-KEY
               MOVE 042222 TO CCC
               MOVE F065 TO CHAR1
               PERFORM READER THRU REXIT.
           ADD 1 TO D.
      *
      ******** CAUSE / FACTOR
      *
           MOVE 1 TO CFF.
           MOVE SPACES TO P-WORK
           WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
           MOVE '                                 CAUSE / FACTOR' TO
               DESCRIPTION.
           WRITE P-REC FROM P-WORK AFTER POSITIONING 1.
           PERFORM C-F-PRINT THRU C-F-EXIT UNTIL CFF GREATER THAN 10.
           MOVE ZERO TO HEAD-COUNT.
      *
      ******** INJURY INDEX
      *
           MOVE SPACES TO P-WORK.
           WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
           MOVE '                                 INJURY - INDEX' TO
               DESCRIPTION.
           WRITE P-REC FROM P-WORK AFTER POSITIONING 1.
           MOVE SPACES TO P-WORK.
           MOVE ' F   S   M   N   Z   T   ' TO DATAA.
           WRITE P-REC FROM P-WORK AFTER POSITIONING 1.
           MOVE SPACES TO P-WORK.
       INJ-PRINT.
           IF F080A = SPACES GO TO CHECK-PILOT.
           PERFORM UNIQUE THRU END-UNIQUE 3 TIMES.
           MOVE 1 TO INJ1.
      *
      ******** CHECK PILOT INJURIES
      *
       CHECK-PILOT.
           IF F08001B (1, 1) = ZERO   NEXT SENTENCE ELSE
               MOVE F08001B (1, 1) TO F08001A (1)
               PERFORM UNIQUE THRU END-UNIQUE.
           MOVE 1 TO INJ1.
           IF F08001B (1, 1) = ZERO   ADD 1 TO D.
      *
      ******** PASSENGER INJURIES
      *
           IF F08001B (2, 3) = ZERO   NEXT SENTENCE ELSE
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               MOVE F08001B (2, 3) TO F08001A (1)
               PERFORM UNIQUE THRU END-UNIQUE.
           MOVE 1 TO INJ1.
           IF F08001B (2, 3) = ZERO   ADD 1 TO D.
      *
      ******** TOTAL ABOARD INJURIES
      *
           IF F08001B (3, 1) = ZERO   NEXT SENTENCE ELSE
               MOVE F08001B (3, 1) TO F08001A (1)
               PERFORM UNIQUE THRU END-UNIQUE.
           MOVE 1 TO INJ1.
       AFTER-INJURY.
           IF F08001B (3, 1) = ZERO   ADD 1 TO D.
           WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
      *
      ******** REMARKS
      *
           IF F08202 = SPACES NEXT SENTENCE ELSE
               MOVE F08202 TO FDATA
               PERFORM MOVE-DIRECT.
           ADD 1 TO D.
      *
      ******** SECOND REMARK
      *
           IF F07801 (1) = '84' OR F083 = SPACES NEXT SENTENCE ELSE
               MOVE F083 TO FDATA
               PERFORM MOVE-DIRECT.
           ADD 1 TO D.
      *
      ******** AIRCRAFT SERIAL NUMBER
      *
           IF F094 = SPACES OR F09401 = 'Z' NEXT SENTENCE ELSE
               MOVE F094 TO FDATA
               PERFORM MOVE-DIRECT.
           ADD 1 TO D.
      *
      ******** IMPACT SEVERITY
      *
           IF F13101 = SPACES OR 'Z' OR ZERO NEXT SENTENCE ELSE
               MOVE SPACES TO HD-KEY
               MOVE 202323 TO CCC
               MOVE F13301 TO CHAR1
               PERFORM READER THRU REXIT.
           ADD 1 TO D.
      *
      ******** ANGLE OF IMPACT
      *
           IF F13302 = SPACES OR ' Z' NEXT SENTENCE ELSE
               MOVE F13302 TO FDATA
               PERFORM MOVE-DIRECT.
           ADD 1 TO D.
      *
      ******** RATE OF DECELERATION
      *
           IF F134 = SPACES OR 'Z' NEXT SENTENCE ELSE
               MOVE SPACES TO HD-KEY
               MOVE 202626 TO CCC
               MOVE F134 TO CHAR1
               PERFORM READER THRU REXIT.
           ADD 1 TO D.
      *
      ******** DIRECTION OF PRINCIPLE DECELERATION
      *
           IF F135 = SPACES OR 'Z' NEXT SENTENCE ELSE
               MOVE SPACES TO HD-KEY
               MOVE 202727 TO CCC
               MOVE F135 TO CHAR1
               PERFORM READER THRU REXIT.
           ADD 1 TO D.
      *
      ******** STOPPING DISTANCE
      *
           IF F136 = SPACES OR '   Z' OR ZERO NEXT SENTENCE ELSE
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147900         EXAMINE F136 REPLACING LEADING ZERO BY SPACES
148000         MOVE F136 TO FDATA
148100         PERFORM MOVE-DIRECT.
148200     ADD 1 TO D.
148300*
148400******** DAMAGE SEVERITY - IMPACT
148500*
148600     IF F13705 = SPACES OR 'Z' NEXT SENTENCE ELSE
148700         MOVE SPACES TO HD-KEY
148800         MOVE 203636 TO CCC
148900         MOVE F13705 TO CHAR1
149000         PERFORM READER THRU REXIT.
149100     ADD 1 TO D.
149200*
149300******** SEATING CONFIGURATION
149400*
149500     IF F138 = SPACES OR 'Z' NEXT SENTENCE ELSE
149600         MOVE SPACES TO HD-KEY
149700         MOVE 203737 TO CCC
149800         MOVE F138 TO CHAR1
149900         PERFORM READER THRU REXIT.
150000     ADD 1 TO D.
150100*
150200******** SEAT FAILURES
150300*
150400     IF F139 = SPACES OR '  Z' OR ZERO NEXT SENTENCE ELSE
150500         EXAMINE F139 REPLACING LEADING ZERO BY SPACES
150600         MOVE F139 TO FDATA
150700         PERFORM MOVE-DIRECT.
150800     ADD 1 TO D.
150900*
151000******** SEAT BELT FAILURES
151100*
151200
151300     IF F140 = SPACES OR '  Z' OR ZERO NEXT SENTENCE ELSE
151400         EXAMINE F140 REPLACING LEADING ZERO BY SPACES
151500         MOVE F140 TO FDATA
151600         PERFORM MOVE-DIRECT.
151700     ADD 1 TO D.
151800*
151900******** DEATHS FROM FIRE AFTER IMPACT
152000*
152100     IF F141 = SPACES OR '  Z' OR ZERO NEXT SENTENCE ELSE
152200         EXAMINE F141 REPLACING LEADING ZERO BY SPACES
152300         MOVE F141 TO FDATA
152400         PERFORM MOVE-DIRECT.
152500     ADD 1 TO D.
152600     MOVE '1' TO READER-SWITCH.
152700*
152800******** ATTITUDE AT IMPACT
152900*
153000     IF F151 = 'ZZZ'
153100         ADD 3 TO D
153200         GO TO AFTER-ATTITUDE.
153300     IF F15101 = 'Z' NEXT SENTENCE ELSE
153400         IF F15101 = SPACES MOVE SPACES TO ATTITUDE-1 ELSE
153500             MOVE SPACES TO HD-KEY
153600             MOVE 206464 TO CCC
153700             MOVE F15101 TO CHAR1
153800             PERFORM READER THRU REXIT
153900             MOVE FDATA TO ATT-WORK
154000             MOVE ATT-02 TO ATTITUDE-1.
154100     ADD 1 TO D.
154200     IF F15102 = 'Z' NEXT SENTENCE ELSE
154300         IF F15102 = SPACES MOVE SPACES TO ATTITUDE-2 ELSE
154400             MOVE SPACE TO HD-KEY
154500             MOVE 206565 TO CCC
154600             MOVE F15102 TO CHAR1
154700             PERFORM READER THRU REXIT
154800             MOVE FDATA TO ATT-WORK
154900             MOVE ATT-02 TO ATTITUDE-2.
155000     ADD 1 TO D.
155100     IF F15103 = 'Z' NEXT SENTENCE ELSE
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155200          IF F15103 = SPACES MOVE SPACES TO ATTITUDE-3 ELSE
155300               MOVE SPACES TO HD-KEY
155400               MOVE 206666 TO CCC
155500               MOVE F15103 TO CHAR1
155600               PERFORM READER THRU REXIT
155700               MOVE FDATA TO ATT-WORK
155800               MOVE ATT-02 TO ATTITUDE-3.
155900      ADD 1 TO D.
156000 AFTER-ATTITUDE.
156100      MOVE '0' TO READER-SWITCH.
156200*
156300******** SPEED AT IMPACT
156400*
156500      IF F152 = SPACES OR '  Z' NEXT SENTENCE ELSE
156600          MOVE F152 TO FDATA
156700          PERFORM MOVE-DIRECT.
156800      ADD 1 TO D.
156900*
157000******** TEST FOR AGRICULTURAL AIRCRAFT
157100*
157200      IF F02501 = 'C' AND (F02502 = 'A' OR 'B' OR 'C' OR 'D')
157300          NEXT SENTENCE ELSE ADD 10 TO D GO TO CABIN-INJURY.
157400*
157500******** KIND OF OPERATION
157600M
157700      IF F192 = SPACES OR 'Z' NEXT SENTENCE ELSE
157800          MOVE SPACES TO HD-KEY
157900          MOVE 252121 TO CCC
158000          MOVE F192 TO CHAR1
158100          PERFORM READER THRU REXIT.
158200      ADD 1 TO D.
158300*
158400******** SHOULDER HARNESS USED
158500*
158600      IF F198 = SPACES OR 'Z' NEXT SENTENCE ELSE
158700          MOVE SPACES TO HD-KEY
158800          MOVE 252727 TO CCC
158900          MOVE F198 TO CHAR1
159000          PERFORM READER THRU REXIT.
159100      ADD 1 TO D.
159200*
159300******** SEAT BELT STATUS
159400*
159500      IF F199 = SPACES OR 'Z' NEXT SENTENCE ELSE
159600          MOVE SPACES TO HD-KEY
159700          MOVE 252828 TO CCC
159800          MOVE F199 TO CHAR1
159900          PERFORM READER THRU REXIT.
160000      ADD 1 TO D.
160100*
160200******** CRASH HELMET STATUS
160300*
160400      IF F204 = SPACES OR 'Z' NEXT SENTENCE ELSE
160500          MOVE SPACES TO HD-KEY
160600          MOVE 253333 TO CCC
160700          MOVE F204 TO CHAR1
160800          PERFORM READER THRU REXIT.
160900      ADD 1 TO D.
161000*
161100******** COCKPIT CRASH PAD STATUS
161200*
161300      IF F205 = SPACES OR 'Z' NEXT SENTENCE ELSE
161400          MOVE SPACES TO HD-KEY
161500          MOVE 253434 TO CCC
161600          MOVE F205 TO CHAR1
161700          PERFORM READER THRU REXIT.
161800      ADD 1 TO D.
161900*
162000******** CRASH BAR STATUS
162100*
162200      IF F206 = SPACES OR 'Z' NEXT SENTENCE ELSE
162300          MOVE SPACES TO HD-KEY
162400          MOVE 253535 TO CCC
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162500             MOVE F206 TO CHAR1
162600             PERFORM READER THRU REXIT.
162700         ADD 1 TO D.
162800*
162900******** OBSTRUCTION STATUS
163000*
163100         IF F20901 = SPACES OR 'Z' NEXT SENTENCE ELSE
163200             MOVE SPACES TO HD-KEY
163300             MOVE 255153 TO CCC
163400             MOVE F20901 TO CHAR1
163500             PERFORM READER THRU REXIT.
163600         ADD 1 TO D.
163700         IF F20902 = SPACES OR 'Z' NEXT SENTENCE ELSE
163800             MOVE SPACES TO HD-KEY
163900             MOVE 255153 TO CCC
164000             MOVE F20902 TO CHAR1
164100             PERFORM READER THRU REXIT.
164200         ADD 1 TO D.
164300         IF F20903 = SPACES OR 'Z' NEXT SENTENCE ELSE
164400             MOVE SPACES TO HD-KEY
164500             MOVE 255153 TO CCC
164600             MOVE F20903 TO CHAR1
164700             PERFORM READER THRU REXIT.
164800         ADD 1 TO D.
164900*
165000******** TERRAIN TYPE
165100*
165200         IF F21001 = SPACES NEXT SENTENCE ELSE
165300             MOVE SPACES TO HD-KEY
165400             MOVE 255456 TO CCC
165500             MOVE F21001 TO CHAR1
165600             PERFORM READER THRU REXIT.
165700         ADD 1 TO D.
165800         IF F21002 = SPACES NEXT SENTENCE ELSE
165900             MOVE SPACES TO HD-KEY
166000             MOVE 255456 TO CCC
166100             MOVE F21003 TO CHAR1
166200             PERFORM READER THRU REXIT.
166300*
166400*                       INJURY SUMMARIES
166500*
166600*            DID INJURY OCCUR IN CABIN
166700*
166800 CABIN-INJURY.
166900*
167000******** COLLECT PAGE 2 INFORMATION ********************************
167700*
167800         IF ADD-TOT-AC = '1'
167900             ADD 1 TO TOT-AC
168000             ADD 1 TO GTOT-AC.
168100         MOVE F080018 (3, 1) TO F0808-01.
168105         DISPLAY 'STATEMENT 168100, F3808-01 = ' F0808-01.
168200         IF F0808-A  = ZERO   GO TO IMPACT-ANGLE.
168600*
168700******** CHECK AND TALLY MINOR OPERATIONAL PHASES
168800*
168900         MOVE 42 TO HISAVE.
169000         MOVE F029 TO SEARCH-CODE.
169100         PERFORM OP-SEARCH THRU END-OP.
169200         IF FOUND-WORD = '1' MOVE ZERO TO FOUND-WORD
169300             GO TO LOAD-ARRAY.
169400         GO TO CHECK-TYPES.
169500*
169600******** CHECK TOTAL ON BOARD AREA FOR VALUES IN INJURY CATEGORIES
169700*
169800 LOAD-ARRAY.
169900         MOVE '0' TO BEEN-THERE.
170000         IF F08001018 (3,1,1) NOT = ZERO
170100             MOVE 1 TO OP
170200             PERFORM SERIOUS-B THRU END-SERIOUS-B.
170300         IF F08001018 (3,1,2) NOT = ZERO
170400             MOVE 2 TO OP
170500             PERFORM SERIOUS-B THRU END-SERIOUS-B.
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170600     IF F08001018 (3,1,3) NOT = ZERO
170700         MOVE 3 TO OP
170800         PERFORM SERIOUS-B THRU END-SERIOUS-B.
170900     IF F08001018 (3,1,4) NOT = ZERO
171000         MOVE 4 TO OP
171100         PERFORM SERIOUS-B THRU END-SERIOUS-B.
171200
171300*
171400******** CHECK AND TALLY TYPES OF ACCIDENTS
171500*
171600 CHECK-TYPES.
171700     MOVE 22 TO HISAVE.
171800     MOVE F02801 TO SEARCH-TYPE.
171900     PERFORM TYPE-SEARCH THRU END-TYPE.
172000     IF FOUND-WORD = '1' MOVE ZERO TO FOUND-WORD
172100         GO TO COLLECT-TYPES.
172200     GO TO IMPACT-ANGLE.
172300
172400 COLLECT-TYPES.
172500     MOVE '0' TO BEEN-THERE.
172600     IF F08001018 (3,1,1) NOT = ZERO
172700         MOVE 1 TO OP
172800         PERFORM TYPE-COLLECT THRU END-COLLECT.
172900     IF F08001018 (3,1,2) NOT = ZERO
173000         MOVE 2 TO OP
173100         PERFORM TYPE-COLLECT THRU END-COLLECT.
173200     IF F08001018 (3,1,3) NOT = ZERO
173300         MOVE 3 TO OP
173400         PERFORM TYPE-COLLECT THRU END-COLLECT.
173500
173600     IF F08001018 (3,1,4) NOT = ZERO
173700         MOVE 4 TO OP
173800         PERFORM TYPE-COLLECT THRU END-COLLECT.
173900
174000 IMPACT-ANGLE.
174200     IF F13302 = SPACES GO TO IMPACT-VELOCITY.
174300     MOVE ZERO TO TALLY.
174400     EXAMINE F13302 TALLYING ALL 'Z'.
174500     IF TALLY NOT = ZERO GO TO IMPACT-VELOCITY.
174600     IF F13302 IS GREATER THAN  ' ' AND LESS THAN  '16'
174700         ADD 1 TO G-ANG-15
174800         ADD 1 TO ANGLE-15.
174900     IF F13302 IS GREATER THAN  '15' AND LESS THAN  '31'
175000         ADD 1 TO G-ANG-30
175100         ADD 1 TO ANGLE-30.
175200     IF F13302 IS GREATER THAN  '30' AND LESS THAN  '46'
175300         ADD 1 TO G-ANG-45
175400         ADD 1 TO ANGLE-45.
175500     IF F13302 IS GREATER THAN  '45' AND LESS THAN  '61'
175600         ADD 1 TO G-ANG-60
175700         ADD 1 TO ANGLE-60.
175800     IF F13302 IS GREATER THAN  '60' AND LESS THAN  '76'
175900         ADD 1 TO G-ANG-75
176000         ADD 1 TO ANGLE-75.
176100     IF F13302 IS GREATER THAN  '75' AND LESS THAN  '90'
176200         ADD 1 TO G-ANG-90
176300         ADD 1 TO ANGLE-90.
176400     IF F13302 IS GREATER THAN  '89'
176500         ADD 1 TO G-ANG-90-PLUS
176600         ADD 1 TO ANGLE-90-PLUS.
176700     ADD 1 TO GTOT-ACC-ANG.
176800     ADD 1 TO TOT-ACC-ANG.
176900     TRANSFORM F13302 FROM SPACES TO ZERO.
177000     MOVE F13302 TO ANGLE-01.
177100     ADD ANGLE-02 TO ANGLE-SUM.
177200     ADD ANGLE-02 TO G-ANG-SUM.
177300     DIVIDE ANGLE-SUM BY TOT-ACC-ANG GIVING AVG-ANGLE  ROUNDED.
177400     DIVIDE G-ANG-SUM BY GTOT-ACC-ANG GIVING G-AVG-ANGLE ROUNDED.
177500
177600 IMPACT-VELOCITY.
177700     EXAMINE F152   REPLACING LEADING ZERO BY SPACES.
177800     IF F152 = SPACES GO TO STOPPING-DISTANCE.
177900     MOVE ZERO TO TALLY.
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178000     EXAMINE F152 TALLYING ALL 'Z'.
178100     IF TALLY NOT = ZERO GO TO STOPPING-DISTANCE.
178200     IF F152 GREATER THAN '   ' AND LESS THAN ' 31'
178300         ADD 1 TO G-VEL-30
178400         ADD 1 TO VEL-30.
178500     IF F152 GREATER THAN ' 30' AND LESS THAN ' 61'
178600         ADD 1 TO G-VEL-60
178700         ADD 1 TO VEL-60.
178800     IF F152 GREATER THAN ' 60' AND LESS THAN ' 91'
178900         ADD 1 TO G-VEL-90
179000         ADD 1 TO VEL-90.
179100     IF F152 GREATER THAN ' 90' AND LESS THAN '120'
179200         ADD 1 TO G-VEL-120
179300         ADD 1 TO VEL-120.
179400     IF F152 GREATER THAN '119'
179500         ADD 1 TO G-VEL-120-PLUS
179600         ADD 1 TO VEL-120-PLUS.
179700     ADD 1 TO TOT-ACC-VEL.
179800     ADD 1 TO GTOT-ACC-VEL.
179900     TRANSFORM F152 FROM SPACES TO ZERO.
180000     MOVE F152 TO VEL-01.
180100     ADD VEL-02 TO VEL-SUM.
180200     ADD VEL-02 TO G-VEL-SUM.
180300     DIVIDE VEL-SUM BY TOT-ACC-VEL GIVING AVG-VEL ROUNDED.
180400     DIVIDE G-VEL-SUM BY GTOT-ACC-VEL GIVING G-AVG-VEL ROUNDED.
180500
180600 STOPPING-DISTANCE.
180700     EXAMINE F136   REPLACING LEADING ZERO BY SPACES.
180800     IF F136 = SPACES GO TO OCCUPANT-INJURY.
180900     MOVE ZERO TO TALLY.
181000     EXAMINE F136 TALLYING ALL 'Z'.
181100     IF TALLY NOT = ZERO GO TO SEAT-BELT-FAILURE.
181200     IF F136 IS GREATER THAN '    ' AND LESS THAN '  59'
181300         ADD 1 TO G-DIST-10
181400         ADD 1 TO DIST-10.
181500     IF F136 IS GREATER THAN '  59' AND LESS THAN ' 120'
181600         ADD 1 TO G-DIST-20
181700         ADD 1 TO DIST-20.
181800     IF F136 IS GREATER THAN ' 119' AND LESS THAN ' 180'
181900         ADD 1 TO G-DIST-30
182000         ADD 1 TO DIST-30.
182100     IF F136 IS GREATER THAN ' 179' AND LESS THAN ' 240'
182200         ADD 1 TO G-DIST-40
182300         ADD 1 TO DIST-40.
182400     IF F136 IS GREATER THAN ' 239' AND LESS THAN ' 300'
182500         ADD 1 TO G-DIST-50
182600         ADD 1 TO DIST-50.
182700     IF F136 IS GREATER THAN ' 299' AND LESS THAN ' 360'
182800         ADD 1 TO G-DIST-60
182900         ADD 1 TO DIST-60.
183000     IF F136 IS GREATER THAN ' 359'
183100     ADD 1 TO G-DIST-60-PLUS
183200         ADD 1 TO DIST-60-PLUS.
183300     ADD 1 TO TOT-ACC-DIST.
183400     ADD 1 TO  GTOT-ACC-DIST.
183500     TRANSFORM F136 FROM SPACES TO ZEROS.
183600     MOVE F136 TO DIST-01.
183700     ADD DIST-02 TO DIST-SUM.
183800     ADD DIST-02 TO G-DIST-SUM.
183900     DIVIDE DIST-SUM BY TOT-ACC-DIST GIVING AVG-DIST ROUNDED.
184000     DIVIDE G-DIST-SUM BY GTOT-ACC-DIST GIVING G-AVG-DIST ROUNDED.
184100 OCCUPANT-INJURY.
184200*
184300*******  NUMERICAL OCCUPANT INJURY SUMMARY
184400*
184500     IF F13705 IS = SPACES OR 'Z' GO TO TERRAIN-CHECK.
184600     PERFORM SEVERITY-TEST THRU END-SEVERITY VARYING
184700         SEVERITY-INDEX FROM 1 BY 1
184800         UNTIL SEVERITY-INDEX GREATER THAN 5.
184900     IF SEVERITY-INDEX IS GREATER THAN 5
185000         GO TO TERRAIN-CHECK.
185100 PERFORM-SERIOUS.
185200     PERFORM SERIOUS-TEST THRU END-SERIOUS VARYING
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185300              SERIOUS-INDEX FROM 1 BY 1
185400              UNTIL SERIOUS-INDEX GREATER THAN 4.
185500*
185600******** SEARCH FOR ACCEPTABLE TERRAIN TYPE.  IF FOUND INCREMENT
185700******** THAT TERRAIN COUNT BY 1.
185800*
185900 TERRAIN-CHECK.
186000     IF F065 = SPACES MOVE 'Z' TO F065.
186100     PERFORM TERRAIN-A THRU END-TERRAIN VARYING TERRAIN-INDEX
186200         FROM 1 BY 1 UNTIL F065 = TERRAIN (TERRAIN-INDEX) OR
186300         TERRAIN-INDEX GREATER THAN 13.
186400     IF TERRAIN-INDEX GREATER THAN 13 GO TO SEAT-BELT-FAILURE.
186500     SET TER-IND TO TERRAIN-INDEX.
186600     ADD 1 TO GTERRAIN-COUNT (TER-IND).
186700     ADD 1 TO TERRAIN-COUNT (TER-IND).
186800 SEAT-BELT-FAILURE.
186900     IF F140 = SPACES OR ZERO  GO TO SEAT-FAILURE.
187000     MOVE ZERO TO TALLY.
187100     EXAMINE F140 TALLYING ALL 'Z'.
187200     IF TALLY NOT = ZERO GO TO SEAT-FAILURE.
187300     ADD 1 TO GTOT-STBLT-ACC.
187400     ADD 1 TO TOT-STBLT-ACC.
187500     TRANSFORM F140 FROM SPACES TO ZERO.
187600     MOVE F140 TO S-B-01.
187700     ADD SEAT-BELT TO TOT-STBLT-FAIL.
187800     ADD SEAT-BELT TO GTOT-STBLT-FAIL.
187900 SEAT-FAILURE.
188000     IF F139 = SPACES OR ZERO GO TO AG-PLANE.
188100     MOVE ZERO TO TALLY.
188200     EXAMINE F139 TALLYING ALL 'Z'.
188300     IF TALLY NOT = ZERO GO TO AG-PLANE.
188400     ADD 1 TO GTOT-ST-ACC.
188500     ADD 1 TO TOT-ST-ACC.
188600     TRANSFORM F139 FROM SPACES TO ZERO.
188700     MOVE F139 TO S-01.
188800     ADD SEAT TO TOT-ST-FAIL.
188900     ADD SEAT TO GTOT-ST-FAIL.
189000
189100 AG-PLANE.
189200     MOVE F012 TO MK.
189300     MOVE F013 TO MOD.
189400     IF MK-MOD = '03932' OR '07113' OR
189500         '03405' OR '12426' OR '14803'
189600         NEXT SENTENCE ELSE GO TO CAUSE-FACTOR-P.
189700     IF F198 = 'A' OR 'B' OR 'C' OR 'E'
189800         ADD 1 TO GS-H-INST
189900         ADD 1 TO S-H-INSTALLED.
190000     IF F198 = 'A' OR 'C' OR 'E'
190100         ADD 1 TO GS-H-USED
190200         ADD 1 TO S-H-USED.
190300     IF F198 = 'B'
190400         ADD 1 TO GS-H-FAILED
190500         ADD 1 TO S-H-FAILED.
190600     IF F204 = 'A'
190700         ADD 1 TO GHEL-USED
190800         ADD 1 TO HELMET-USED.
190900     IF F204 = 'B'
191000         ADD 1 TO GHEL-UNUSED
191100         ADD 1 TO HELMET-UNUSED.
191200*
191300******** CAUSE-FACTOR SUMMARY
191400*
191500 CAUSE-FACTOR-P.
191600     MOVE 487 TO HISAVE.
191700     MOVE 1 TO CFF.
191710*
191720******** THIS PERFORM IS DONE 10 TIMES BECAUSE THERE ARE A POSSIBLE
191730******* 10 CAUSE/FACTORS IN THE CAUSE-FACTOR FIELD
191740*
191800     PERFORM C-F-SEARCH THRU END-CF-SEARCH UNTIL CFF IS
191900         GREATER THAN 10.
192000     GO TO READ-MTSB.
192100*
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192200******** PRINT SUMMARIES
192300*
192400 PRINT-SUMMARY.
192500     WRITE P-REC FROM SPACE-LINE      AFTER POSITIONING 0.
192600     WRITE P-REC FROM SUMMARY-HEAD-1 AFTER POSITIONING 3.
192700     WRITE P-REC FROM SUMMARY-HEAD-2 AFTER POSITIONING 1.
192800     WRITE P-REC FROM SPACE-LINE      AFTER POSITIONING 2.
192900     MOVE ZERO TO D.
193000 STOP-SUMMARY.
193100*
193200******** FILL PAGE 1 FIELDS
193300*
193400     MOVE HOLD-MAKE-NAME TO PAGE-1-MAKE.
193500     MOVE HOLD-MODEL TO PAGE-1-MOD.
193600     MOVE TOT-AC                TO PG-1-TOTA.
193700     MOVE TOT-AC-TYPE TO PG-1-TOTAB.
193800     MOVE TOT-OCC               TO PG-1-TOTB.
193900     MOVE AV-OCC                TO PG-1-TOTC.
194000     MOVE TOT-FAT               TO PG-1-TOTD.
194100     MOVE TOT-SER               TO PG-1-TOTE.
194200     MOVE TOT-MNR               TO PG-1-TOTF.
194300     MOVE TOT-NON               TO PG-1-TOTH.
194400     MOVE PG-1-SER (1, 1)       TO PG-1-TOTI.
194500     MOVE PG-1-SER (1, 2)       TO PG-1-TOTJ.
194600     MOVE PG-1-SER (1, 3)       TO PG-1-TOTK.
194700     MOVE PG-1-SER (1, 4)       TO PG-1-TOTL.
194800     MOVE PG-1-SER (2, 1)       TO PG-1-TOTM.
194900     MOVE PG-1-SER (2, 2)       TO PG-1-TOTN.
195000     MOVE PG-1-SER (2, 3)       TO PG-1-TOTP.
195100     MOVE PG-1-SER (2, 4)       TO PG-1-TOTQ.
195200     MOVE PG-1-SER (3, 1)       TO PG-1-TOTR.
195300     MOVE PG-1-SER (3, 2)       TO PG-1-TOTS.
195400     MOVE PG-1-SER (3, 3)       TO PG-1-TOTT.
195500     MOVE PG-1-SER (3, 4)       TO PG-1-TOTU.
195600     MOVE PG-1-SER (4, 1)       TO PG-1-TOTV.
195700     MOVE PG-1-SER (4, 2)       TO PG-1-TOTW.
195800     MOVE PG-1-SER (4, 3)       TO PG-1-TOTX.
195900     MOVE PG-1-SER (4, 4)       TO PG-1-TOTY.
196000     PERFORM PAGE-1-P THRU END-PG-1 UNTIL D = 23.
196100     PERFORM SKIP-TO-HEAD.
196200*
196300******** FILL PAGE 2 FIELDS
196400*
196500     MOVE TOT-T-O TO PG-2-TO.
196600     MOVE TOT-FLY TO PG-2-IF.
196700     MOVE TOT-LDG TO PG-2-LDG.
196800     MOVE FAT-TS TO PG-2-OTHERFAT.
196900     MOVE TOT-TS TO PG-2-OTHER.
197000     MOVE FAT-TO  TO PG-2-TOFAT.
197100     MOVE FAT-INFLT TO PG-2-IFFAT.
197200     MOVE TOT-NR TO PG-2-NR.
197300     MOVE FAT-NR TO PG-2-NRFAT.
197400     MOVE FAT-LDG    TO PG-2-LDGFAT.
197500     MOVE ZERO TO SAVE-SUB-01.
197600     MOVE 1 TO SS.
197700     MOVE 1 TO OP.
197800     MOVE ZERO TO SSS.
197900*
198000******** SEARCH OPERATIONAL PHASES TOTAL FIELD FOR  8 HIGHEST
198100******** TOTAL NO. OF ACCIDENTS.
198200*
198300 SEARCH-OP-A.
198400     MOVE OP-PH-04 (1, 5) TO OP-PH-HOLD.
198500     IF SS GREATER THAN 8
198600     DISPLAY 'SAVE-SUB-01 = ' SAVE-SUB-01
198700         MOVE 1 TO SS
198800         GO TO OP-HEADERS.
198900 SEARCH-OP-B.
199000     IF OP GREATER THAN 42
199100         MOVE 1 TO OP
199200         ADD 1 TO SS
199300         GO TO SEARCH-OP-A.
199400*
```

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199500******** SEE IF SUBSCRIPT HAS ALREADY BEEN USED
199600*
199700      PERFORM BEGIN-SUB-SEARCH THRU END-SUB-SEARCH.
199800      IF FOUND-WORD = '1'
199900          ADD 1 TO OP
200000          GO TO SEARCH-OP-B.
200100      IF OP-PH-04 (OP, 5) IS GREATER THAN OP-PH-HOLD
200200          OR EQUAL TO OP-PH-HOLD
200300          MOVE OP-PH-04 (OP, 5) TO OP-PH-HOLD
200400          IF OP-PH-HOLD = ZERO
200500              MOVE 99 TO SAVE-SUB (SS) ELSE
200600              MOVE OP TO SAVE-SUB (SS).
200700      ADD 1 TO OP.
200800      GO TO SEARCH-OP-B.
200900 OP-HEADERS.
201000      MOVE SPACES TO MINOR-P1 (SS).
201100      MOVE '1' TO READER-SWITCH.
201200      MOVE SPACES TO PAGE-2-03D (SS).
201300      MOVE SAVE-SUB (SS) TO SSS.
201400      IF NOT (SSS = 99 OR ZERO)
201500      MOVE SPACES TO HD-KEY
201600      MOVE 014851 TO CCC
201700      MOVE OP-PH (SSS) TO CODE2
201800      PERFORM READER THRU REXIT
201900      MOVE HDER TO MINOR-P1 (SS).
202000      MOVE SS TO MP-NO (SS).
202100      MOVE '. ' TO PERIOD-04 (SS).
202200      IF SSS = 99 OR ZERO NEXT SENTENCE ELSE
202300      SUBTRACT OP-PH-04 (SSS, 5) FROM OP-PH-04 (43, 5)
202400      SUBTRACT OP-PH-04 (SSS, 1) FROM OP-PH-04 (43, 1)
202500      SUBTRACT OP-PH-04 (SSS, 2) FROM OP-PH-04 (43, 2)
202600      SUBTRACT OP-PH-04 (SSS, 3) FROM OP-PH-04 (43, 3)
202700      SUBTRACT OP-PH-04 (SSS, 4) FROM OP-PH-04 (43, 4)
202800      MOVE OP-PH-04 (SSS, 5) TO TOT-ACC-MP (SS)
202900      MOVE OP-PH-04 (SSS, 1) TO FAT-INJ-MP (SS)
203000      MOVE OP-PH-04 (SSS, 2) TO SER-INJ-MP (SS)
203100      MOVE OP-PH-04 (SSS, 3) TO MIN-INJ-MP (SS)
203200      MOVE OP-PH-04 (SSS, 4) TO NON-INJ-MP (SS).
203300      ADD 1 TO SS.
203400      IF SS GREATER THAN 8  NEXT SENTENCE ELSE
203500          GO TO OP-HEADERS.
203600      MOVE SPACES TO PAGE-2-03D (9).
204300      MOVE 09 TO MP-NO (9).
204400      MOVE '. ' TO PERIOD-04 (9).
204500      MOVE 'OTHERS' TO MINOR-P1 (9).
204600      MOVE OP-PH-04 (43, 5) TO TOT-ACC-MP (9).
204700      MOVE OP-PH-04 (43, 1) TO FAT-INJ-MP (9).
204800      MOVE OP-PH-04 (43, 2) TO SER-INJ-MP (9).
204900      MOVE OP-PH-04 (43, 3) TO MIN-INJ-MP (9).
205000      MOVE OP-PH-04 (43, 4) TO NON-INJ-MP (9).
205900*
206000******** SEARCH TYPE HEADERS FOR  6 HIGHEST
206100*
206200      MOVE ZERO TO SAVE-SUB-01.
206300      MOVE 1 TO SS.
206400      MOVE 1 TO OP.
206500      MOVE ZERO TO SSS.
206600 SEARCH-TYP-A.
206700      MOVE TYP-TOT (1, 5) TO TYP-HOLD.
206800      IF SS GREATER THAN 6
206900          MOVE 1 TO SS
207000      DISPLAY 'SAVE-SUB-01-TYPS ' SAVE-SUB-01
207100          GO TO TYP-HEADERS.
207200 SEARCH-TYP-B.
207300      IF OP GREATER THAN 22
207400          MOVE 1 TO OP
207500          ADD 1 TO SS
207600          GO TO SEARCH-TYP-A.
207700      PERFORM BEGIN-SUB-SEARCH THRU END-SUB-SEARCH.
207800      IF FOUND-WORD = '1'
207900          ADD 1 TO OP
208000          GO TO SEARCH-TYP-B.
208100      IF TYP-TOT (OP, 5) IS GREATER THAN TYP-HOLD OR = TYP-HOLD
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           MOVE TYP-TOT (OP, 5) TO TYP-HOLD
           IF TYP-HOLD = ZERO
               MOVE 99 TO SAVE-SUB (SS) ELSE
               MOVE OP TO SAVE-SUB (SS).
       ADD 1 TO OP.
       GO TO SEARCH-TYP-8.
   TYP-HEADERS.
       MOVE SPACES TO TYP-DESC (SS).
       MOVE SPACES TO PAGE-2-03DA (SS).
       MOVE SAVE-SUB (SS) TO SSS.
       IF NOT (SSS = 99 OR ZERO)
       MOVE SPACES TO HD-KEY
       MOVE 014447 TO CCC
       MOVE TYP-OP (SSS) TO CHAR2
       PERFORM READER THRU REXIT
       MOVE HDER TO TYP-DESC (SS).
       MOVE SS TO TYP-NO (SS).
       MOVE '. ' TO PERIODT-04 (SS).
       IF SSS = 99 OR ZERO NEXT SENTENCE ELSE
       SUBTRACT TYP-TOT (SSS, 5) FROM TYP-TOT (23, 5)
       SUBTRACT TYP-TOT (SSS, 1) FROM TYP-TOT (23, 1)
       SUBTRACT TYP-TOT (SSS, 2) FROM TYP-TOT (23, 2)
       SUBTRACT TYP-TOT (SSS, 3) FROM TYP-TOT (23, 3)
       SUBTRACT TYP-TOT (SSS, 4) FROM TYP-TOT (23, 4)
       MOVE TYP-TOT (SSS, 5) TO TOT-ACC-TYP (SS)
       MOVE TYP-TOT (SSS, 1) TO FAT-INJ-TYP (SS)
       MOVE TYP-TOT (SSS, 2)  TO SER-INJ-TYP (SS)
       MOVE TYP-TOT (SSS, 3) TO MIN-INJ-TYP (SS)
       MOVE TYP-TOT (SSS, 4) TO NON-INJ-TYP (SS).
       ADD 1 TO SS.
       IF SS GREATER THAN  6 NEXT SENTENCE ELSE
           GO TO TYP-HEADERS.
       MOVE SPACES TO PAGE-2-03DA (7).
       MOVE SPACES TO PAGE-2-03DA (8).
       SUBTRACT TYP-TOT (22, 5) FROM TYP-TOT (23, 5).
       SUBTRACT TYP-TOT (22, 1) FROM TYP-TOT (23, 1).
       SUBTRACT TYP-TOT (22, 2) FROM TYP-TOT (23, 2).
       SUBTRACT TYP-TOT (22, 3) FROM TYP-TOT (23, 3).
       SUBTRACT TYP-TOT (22, 4) FROM TYP-TOT (23, 4).
       MOVE 07 TO TYP-NO (7).
       MOVE '. ' TO PERIODT-04 (7).
       MOVE 'OTHERS' TO TYP-DESC (7).
       MOVE TYP-TOT (23, 5) TO TOT-ACC-TYP (7).
       MOVE TYP-TOT (23, 1) TO FAT-INJ-TYP (7).
       MOVE TYP-TOT (23, 2) TO SER-INJ-TYP (7).
       MOVE TYP-TOT (23, 3) TO MIN-INJ-TYP (7).
       MOVE TYP-TOT (23, 4) TO NON-INJ-TYP (7).
       MOVE 8 TO TYP-NO (8).
       MOVE '. ' TO PERIODT-04 (8).
       MOVE 'NOT REPORTED' TO TYP-DESC (8).
       MOVE TYP-TOT (22, 5) TO TOT-ACC-TYP (8).
       MOVE TYP-TOT (22, 1) TO FAT-INJ-TYP (8).
       MOVE TYP-TOT (22, 2) TO SER-INJ-TYP (8).
       MOVE TYP-TOT (22, 3) TO MIN-INJ-TYP (8).
       MOVE TYP-TOT (22, 4) TO NON-INJ-TYP (8).
       PERFORM PAGE-2-P THRU END-PG-2 UNTIL D = 34.
   END-PAGE-2.
       PERFORM SKIP-TO-HEAD.
*
******** LOAD PAGE 3 OCCUPANT INJURY TABLE.
*
       PERFORM LOAD-PG-3 THRU END-LOAD-3
           VARYING S-INDEX FROM 1 BY 1
           UNTIL S-INDEX GREATER THAN 5
           AFTER SERIOUS-INDEX FROM 1 BY 1
           UNTIL SERIOUS-INDEX GREATER THAN 1.
       MOVE 'EXTREME ' TO SEV-NAME (1).
       MOVE 'SEVERE  ' TO SEV-NAME (2).
       MOVE 'MODERATE' TO SEV-NAME (3).
       MOVE 'MINOR   ' TO SEV-NAME (4).
       MOVE 'NONE    ' TO SEV-NAME (5).
       MOVE TOT-ACC-ANG TO TOT-IMPACT.
       MOVE TOT-ACC-VEL TO VEL-IMP.
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           MOVE TOT-ACC-DIST TO STOP-DIST.
           PERFORM PAGE-3-P THRU END-PG-3 UNTIL D = 25.
           PERFORM SKIP-TO-HEAD.
       END-PAGE-3.
      *
      ******** LOAD PAGE 4
      *
           MOVE TOT-ST-ACC TO SEAT-FAIL-ACC.
           MOVE TOT-ST-FAIL TO SEAT-FAIL.
           MOVE TOT-STBLT-ACC TO SEAT-BELT-ACC.
           MOVE TOT-STBLT-FAIL TO SEAT-BELT-FAIL.
           MOVE S-H-USED TO SH-HARN-USED.
           MOVE S-H-FAILED TO SH-HARN-FAIL.
           MOVE HELMET-USED TO CRASH-HEL-USED.
           MOVE HELMET-UNUSED TO CRASH-HEL-UNUSED.
      *
      ******** LOAD PAGE 4 TERRAIN TYPE TABLE
      *
       LOAD-4.
           PERFORM LOAD-PG-4 THRU END-LOAD-4 VARYING TERRAIN-INDEX
               FROM 1 BY 1 UNTIL TERRAIN-INDEX GREATER THAN 13.
           MOVE SPACES TO PAGE-4-WORK.
           MOVE 1 TO ITER-4.
           MOVE PCT-TER (1) TO PCT-HOLD.
           MOVE ZERO TO TER-IND.
           PERFORM SORT-PG-4 THRU END-SORT.
       LOAD-4-A.
           PERFORM PAGE-4-P THRU END-PG-4 UNTIL D = 29.
           PERFORM SKIP-TO-HEAD.
       END-PAGE-4.      EXIT.
      *
      *
      ********                PRINT PAGE 5
      ********          PRINT CAUSE/FACTOR SUMMARIES.
      *
       LOAD-5.
           MOVE 1 TO C-INITIAL.
           MOVE ZERO TO C-SAVE-01.
           MOVE PAGE-5 (1) TO P-WORK-02B.
           WRITE P-REC FROM P-WORK       AFTER POSITIONING 3.
           MOVE PAGE-5 (2) TO P-WORK-02B.
           WRITE P-REC FROM P-WORK       AFTER POSITIONING 2.
           MOVE PAGE-5 (3) TO P-WORK-02B.
           WRITE P-REC FROM P-WORK       AFTER POSITIONING 1.
           MOVE PAGE-5 (5) TO P-WORK-02B.
           WRITE P-REC FROM P-WORK       AFTER POSITIONING 2.
           WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
           MOVE 4 TO C-SV-LIMIT.
      *
      ******** PRINT PILOT SUMMARY
      *
           MOVE ZERO TO C-SAVE.
           PERFORM SEARCH-FACTOR THRU END-FACTOR.
      *
      ******** PRINT COPILOT SUMMARY
      *
           DISPLAY 'C-HI ' C-HI 'C-INITIAL ' C-INITIAL.
           MOVE C-HI TO C-INITIAL.
           MOVE PAGE-5 (6) TO P-WORK-02B.
           WRITE P-REC FROM P-WORK       AFTER POSITIONING 2.
           MOVE ZERO TO C-SAVE-01.
           MOVE 2 TO C-SV-LIMIT.
           MOVE ZERO TO C-SAVE.
           PERFORM SEARCH-FACTOR THRU END-FACTOR.
      *
      ******** PRINT DUAL STUDENT SUMMARY
      *
           DISPLAY 'C-HI ' C-HI 'C-INITIAL ' C-INITIAL.
           MOVE C-HI TO C-INITIAL.
           MOVE PAGE-5 (7) TO P-WORK-02B.
           WRITE P-REC FROM P-WORK       AFTER POSITIONING 2.
           MOVE ZERO TO C-SAVE-01.
           MOVE C-HI TO C-INITIAL.
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222800          MOVE ZERO TO C-SAVE.
222900          PERFORM SEARCH-FACTOR THRU END-FACTOR.
223000*
223100******** PRINT CHECK PILOT SUMMARY
223200*
223300          DISPLAY 'C-HI ' C-HI 'C-INITIAL ' C-INITIAL.
223400          MOVE C-HI TO C-INITIAL.
223500          MOVE PAGE-5 (8) TO P-WORK-02B.
223600          WRITE P-REC FROM P-WORK      AFTER POSITIONING 2.
223700          MOVE C-HI TO C-INITIAL.
223800          MOVE ZERO TO C-SAVE-01.
223900          MOVE ZERO TO C-SAVE.
224000          PERFORM SEARCH-FACTOR THRU END-FACTOR.
224100*
224200******** PRINT AIRFRAME SUMMARY
224300*
224400          DISPLAY 'C-HI ' C-HI 'C-INITIAL ' C-INITIAL.
224500          MOVE C-HI TO C-INITIAL.
224600          MOVE PAGE-5 (9) TO P-WORK-02B.
224700          WRITE P-REC FROM P-WORK      AFTER POSITIONING 2.
224800          MOVE C-HI TO C-INITIAL.
224900          MOVE ZERO TO C-SAVE-01.
225000          MOVE ZERO TO C-SAVE.
225100          PERFORM SEARCH-FACTOR THRU END-FACTOR.
225200*
225300******** PRINT MISC ACTS & CONDITIONS SUMMARY
225400*
225500          DISPLAY 'C-HI ' C-HI 'C-INITIAL ' C-INITIAL.
225600          MOVE C-HI TO C-INITIAL.
225700              MOVE 4 TO C-SV-LIMIT.
225800          MOVE PAGE-5 (10) TO P-WORK-02B.
225900              WRITE P-REC FROM P-WORK       AFTER POSITIONING 2.
226000          MOVE C-HI TO C-INITIAL.
226100              MOVE ZERO TO C-SAVE-01.
226200          MOVE ZERO TO C-SAVE.
226300              PERFORM SEARCH-FACTOR THRU END-FACTOR.
226400 END-PAGE-5.    EXIT.
226500 EOJ.
226600*
226700******** PRINT GRAND TOTAL SUMMARIES
226800*
226900********                FILL PAGE 1
227000*
227100*
227200          MOVE '                                             * * * * *  GRAN
227300-         'D TOTAL ACCIDENT SUMMARY  * * * * *' TO SUMMARY-HEAD-1.
227400          PERFORM PRINT-SUMMARY.
227500          MOVE 'ALL' TO PAGE-1-MAKE.
227600          MOVE 'ALL' TO PAGE-1-MOD.
227700          MOVE GTOT-AC              TO PG-1-TOTA.
227710          MOVE GTOT-AC-TYPE TO PG-1-TOTAB.
227800          MOVE GTOT-OCC             TO PG-1-TOTB.
227900          MOVE GAVG-OCC             TO PG-1-TOTC.
228000          MOVE GTOT-FAT             TO PG-1-TOTD.
228100          MOVE GTOT-SER             TO PG-1-TOTE.
228200          MOVE GTOT-MNR             TO PG-1-TOTF.
228300          MOVE GTOT-NON             TO PG-1-TOTH.
228400          MOVE G-PG-1 (1, 1)        TO PG-1-TOTI.
228500          MOVE G-PG-1 (1, 2)        TO PG-1-TOTJ.
228600          MOVE G-PG-1 (1, 3)        TO PG-1-TOTK.
228700          MOVE G-PG-1 (1, 4)        TO PG-1-TOTL.
228800          MOVE G-PG-1 (2, 1)        TO PG-1-TOTM.
228900          MOVE G-PG-1 (2, 2)        TO PG-1-TOTN.
229000          MOVE G-PG-1 (2, 3)        TO PG-1-TOTP.
229100          MOVE G-PG-1 (2, 4)        TO PG-1-TOTQ.
229200          MOVE G-PG-1 (3, 1)        TO PG-1-TOTR.
229300          MOVE G-PG-1 (3, 2)        TO PG-1-TOTS.
229400          MOVE G-PG-1 (3, 3)        TO PG-1-TOTT.
229500          MOVE G-PG-1 (3, 4)        TO PG-1-TOTU.
229600          MOVE G-PG-1 (4, 1)        TO PG-1-TOTV.
229700          MOVE G-PG-1 (4, 2)        TO PG-1-TOTW.
229800          MOVE G-PG-1 (4, 3)        TO PG-1-TOTX.
229900          MOVE G-PG-1 (4, 4)        TO PG-1-TOTY.
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230000     PERFORM PAGE-1-P THRU END-PG-1 UNTIL D = 24.
230100*
230200*********          FILL AND PRINT PG 2 GRAND TOTAL
230300*
230400     MOVE GTOT-T-O TO    PG-2-TO.
230500     MOVE GTOT-FLY TO    PG-2-IF.
230600     MOVE GTOT-LDG TO    PG-2-LDG.
230700     MOVE GFAT-TO  TO    PG-2-TOFAT.
230800     MOVE GFAT-INFLT TO  PG-2-IFFAT.
230900     MOVE GFAT-LDG TO    PG-2-LDGFAT.
231000     MOVE GTOT-TS TO PG-2-OTHER.
231100     MOVE GFAT-TS TO PG-2-OTHERFAT.
231200     MOVE GTOT-NR TO PG-2-NR.
231300     MOVE GFAT-NR TO PG-2-NRFAT.
231400     MOVE ZERO TO SAVE-SUB-01.
231500     MOVE 1 TO SS.
231600     MOVE ZERO TO SSS.
231700     MOVE 1 TO OP.
231800     MOVE GTOT-TYP-01 TO TYP-TOT-01.
231900     MOVE GTOT-OP-01 TO OP-PH-TOT.
232000     PERFORM SKIP-TO-HEAD.
232100     PERFORM SEARCH-OP-A THRU TYP-HEADERS.
232200*
232300*********     FILL AND PRINT PG 3 GRAND TOTALS
232400*
232500     MOVE G-ANG-15 TO ANGLE-15.
232600     MOVE G-ANG-30 TO ANGLE-30.
232700     MOVE G-ANG-45 TO ANGLE-45.
232800     MOVE G-ANG-60 TO ANGLE-60.
232900     MOVE G-ANG-75 TO ANGLE-75.
233000     MOVE G-ANG-90 TO ANGLE-90
233100     MOVE G-ANG-90-PLUS TO ANGLE-90-PLUS
233200     MOVE G-VEL-30    TO VEL-30.
233300     MOVE G-VEL-60    TO VEL-60.
233400     MOVE G-VEL-90    TO VEL-90.
233500     MOVE G-VEL-120   TO VEL-120.
233600     MOVE G-VEL-120-PLUS TO VEL-120-PLUS.
233700     MOVE G-DIST-10   TO   DIST-10.
233800     MOVE G-DIST-20   TO   DIST-20.
233900     MOVE G-DIST-30   TO   DIST-30.
234000     MOVE G-DIST-40   TO   DIST-40.
234100     MOVE G-DIST-50   TO   DIST-50.
234200     MOVE G-DIST-60   TO   DIST-60
234300     MOVE G-DIST-60-PLUS TO DIST-60-PLUS.
234400     MOVE  G-SERIOUS TO SERIOUSNESS.
234500     MOVE GTOT-ACC-ANG TO TOT-ACC-ANG.
234600     MOVE GTOT-ACC-VEL TO TOT-ACC-VEL.
234700     MOVE GTOT-ACC-DIST TO TOT-ACC-DIST.
234800     MOVE G-AVG-ANGLE TO AVG-ANGLE.
234900     MOVE G-AVG-VEL TO AVG-VEL.
235000     MOVE G-AVG-DIST TO AVG-DIST.
235100     PERFORM END-PAGE-2.
235200*
235300*********     FILL AND PRINT PG 4 GRAND TOTALS
235400*
235500     MOVE GTOT-ST-ACC          TO SEAT-FAIL-ACC.
235600     MOVE GTOT-ST-FAIL         TO  SEAT-FAIL.
235700     MOVE GTOT-STBLT-ACC       TO  SEAT-BELT-ACC.
235800     MOVE GTOT-STBLT-FAIL      TO  SEAT-BELT-FAIL.
235900     MOVE GS-H-USED            TO  SH-HARN-USED.
236000     MOVE GS-H-FAILED          TO  SH-HARN-FAIL.
236100     MOVE GHEL-USED       TO  CRASH-HEL-USED.
236200     MOVE GHEL-UNUSED     TO  CRASH-HEL-UNUSED.
236300     MOVE GTOT-AC-TYPE TO TOT-AC-TYPE.
236400     MOVE GTERRAIN-01     TO TERRAIN-001.
236500     PERFORM LOAD-4 THRU END-PAGE-4.
236600*
236700*********       LOAD AND PRINT PAGE 5 GRAND TOTALS
236800*
236900     MOVE '                               CAUSE / FACTOR GRAND SUMM
237000-        'ARY' TO P-REC.
237100     WRITE P-REC AFTER POSITIONING 2.
237200     MOVE G-CAUSE-01 TO CAUSE-01.
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        MOVE G-CAUSE-FAT-01 TO CAUSE-FATAL-01.
        MOVE G-CAUSE-NONFAT-01 TO CAUSE-NONFAT-01.
        MOVE ZERO TO C-SAVE-01.
        MOVE ZERO        TO CAUSE-77.
        PERFORM LOAD-5 THRU END-PAGE-5.
        CLOSE      HEAD PRT.
        STOP RUN.
    UNIQUE.
        MOVE ZERO TO INJ2.
        IF F08001A (INJ1) = SPACES
            ADD 1 TO D, INJ1
            GO TO END-UNIQUE.
    TRANS-INJURY.
        ADD 1 TO INJ2.
        IF INJ2 GREATER THAN 6 GO TO AFTER-TRANS.
        EXAMINE F0800101A (INJ1, INJ2) REPLACING LEADING ZEROS
                    BY SPACES.
        GO TO TRANS-INJURY.
    AFTER-TRANS.
        MOVE F08001A (INJ1) TO FDATA.
        PERFORM MOVE-DIRECT.
        ADD 1 TO D, INJ1.
    END-UNIQUE.     EXIT.
    READER.
        MULTIPLY KYB BY KYB GIVING SUM-A.
        ADD KYA TO SUM-A.
        DIVIDE SUM-A BY 2999 GIVING DIVIDEND-HOLD
            REMAINDER DIVIDE-HOLD.
        DIVIDE DIVIDE-HOLD BY 32 GIVING TRACK-ID.
        MOVE CCC TO KYF.
        MOVE CODE4 TO KYG.
    READER-X.
        READ HEAD INVALID KEY MOVE HD-KEY TO ERR
            DISPLAY 'HD-KEY ERROR = ',  ERR
            MOVE ERR-RT TO HD   GO TO REXIT.
        MOVE HDER TO FDATA.
        IF READER-SWITCH = '1' GO TO REXIT.
    BUILD-LINE.
        PERFORM MOVE-DIRECT.
*
******** HEAD-COUNT UNEQUAL TO 1 OR 0 SUPPRESSES TH DESCRIPTION
******** PREVIOUSLY TAKEN FROM TABLE.  MAKE SURE IT IS SET TO PROP
******** VALUE BEFORE PERFORMING THIS ROUTINE.
*
        IF NOT (HEAD-COUNT = 1 OR 0)
        MOVE SPACES TO DESCRIPTION.
    REXIT.     EXIT.
    SEVERITY-TEST.
        IF SEV (SEVERITY-INDEX) IS = F13705
            GO TO PERFORM-SERIOUS.
    END-SEVERITY.    EXIT.
    SERIOUS-TEST.
        SET S-INDEX TO SEVERITY-INDEX.
        SET GS-INDEX TO S-INDEX.
        SET GSERIOUS-INDEX TO SERIOUS-INDEX.
        SET SER-IND TO SERIOUS-INDEX.
        MOVE F08001018 (3, 1, SER-IND)       TO INJURY.
        IF INJURY NOT = ZEROS AND INJURY IS NUMERIC
            ADD INJURY TO GS (GS-INDEX, GSERIOUS-INDEX)
            ADD INJURY TO S (S-INDEX, SERIOUS-INDEX).
    END-SERIOUS.     EXIT.
    TERRAIN-A.
        MOVE SPACES TO DUMBO.
    END-TERRAIN.     EXIT.
    C-F-PRINT.
        IF F078 (CFF) = SPACES OR (F07801 (CFF) = '84' AND
            F0780302 (CFF)  = 'J') NEXT SENTENCE ELSE
            ADD 1 TO HEAD-COUNT
            MOVE SPACES TO HD-KEY
            MOVE 061766 TO CCC
            MOVE F07801 (CFF) TO HOLD-KEY-1
            MOVE F07803 (CFF) TO HOLD-KEY-2
            MOVE HOLD-KEY TO CODE4
```

```
           MOVE '0' TO READER-SWITCH
           PERFORM READER THRU REXIT.
       ADD 1 TO D.
       ADD 1 TO CFF.
C-F-EXIT.          EXIT.
MOVE-DIRECT.
       MOVE DESC (D) TO DESCRIPTION.
       MOVE FDATA TO DATAA.
       WRITE P-REC FROM P-WORK AFTER POSITIONING 1 EOP
           MOVE SPACES TO P-REC
           WRITE P-REC AFTER POSITIONING 0
           WRITE P-REC AFTER POSITIONING 3.
END-DIRECT.            EXIT.
OP-SEARCH.
       MOVE ZERO TO LO.
       MOVE HISAVE  TO HI.
AB.    COMPUTE I = (HI + LO) / 2.
       IF SEARCH-CODE LESS THAN OP-PH (I)
           MOVE I TO HI
           GO TO BA.
       IF SEARCH-CODE GREATER THAN OP-PH (I)
           MOVE I TO LO
           GO TO BA.
       MOVE '1' TO FOUND-WORD.
       GO TO END-OP.
BA.    IF I LESS THAN (HI - LO) GO TO AB.
END-OP. EXIT.
*
******** I IS DEFINED IN OP-SEARCH
******** OP IS DEFINED IN LOAD-ARRAY
*
SERIOUS-B.
       MOVE F08001018 (3,1,OP) TO INJ-01.
       IF INJURY NOT = ZERO AND INJURY IS NUMERIC
           ADD INJURY TO OP-PH-04 (43, OP)
           ADD INJURY TO GTOT-OP (43, OP)
           ADD INJURY TO GTOT-OP (I, OP)
           ADD INJURY TO OP-PH-04 (I, OP).
       IF INJURY NOT = ZERO AND INJURY IS NUMERIC AND
           BEEN-THERE = '0'
           ADD 1 TO OP-PH-04 (43, 5)
           ADD 1 TO GTOT-OP (43, 5)
           ADD 1       TO GTOT-OP (I, 5)
           ADD 1       TO OP-PH-04 (I, 5)
           MOVE '1' TO BEEN-THERE.
       DISPLAY 'SERIOUS-B ''INJURY = ' INJURY.
END-SERIOUS-B.  EXIT.
TYPE-SEARCH.
       MOVE ZERO TO LO.
       MOVE HISAVE TO HI.
AC.    COMPUTE I = (HI + LO) / 2.
       IF SEARCH-TYPE  LESS THAN TYP-OP (I)
           MOVE I TO HI
           GO TO CA.
       IF SEARCH-TYPE GREATER THAN TYP-OP (I)
           MOVE I TO LO
           GO TO CA.
       MOVE '1' TO FOUND-WORD.
       GO TO END-TYPE.
CA.    IF I LESS THAN (HI - LO) GO TO AC.
END-TYPE.    EXIT.
*
******** I IS DEFINED IN TYPE-SEARCH
******** OP IS DEFINED IN COLLECT-TYPES
*
TYPE-COLLECT.
       MOVE F08001018 (3,1,OP) TO INJ-01.
       TRANSFORM INJ-01 FROM SPACES TO ZEROS.
       IF INJURY NOT = ZERO AND INJURY IS NUMERIC
           ADD INJURY TO GTOT-TYP (23, OP)
           ADD INJURY TO TYP-TOT (23, OP)
           ADD INJURY TO GTOT-TYP (I, OP)
           ADD INJURY TO TYP-TOT (I, OP).
```

```
251900     IF INJURY NOT = ZERO AND INJURY IS NUMERIC AND
252000        BEEN-THERE = '0'
252100        ADD 1 TO GTOT-TYP (23, 5)
252200        ADD 1 TO TYP-TOT (23, 5)
252300        ADD 1     TO GTOT-TYP (I, 5)
252400        ADD 1     TO TYP-TOT (I, 5)
252500        MOVE '1' TO BEEN-THERE.
252600 END-COLLECT.    EXIT.
252700 C-F-SEARCH.
252800     MOVE 487 TO HISAVE.
252900     IF F078 (CFF) = SPACES GO TO PRE-END-CF.
253000     IF F07801 (CFF) = '64' OR '65' OR '66' OR '67' OR '70' OR
253100                       '88'
253200     DISPLAY 'CFF = ' CFF  '  F07801 =  ' F07801 (CFF)
253300        MOVE F07801 (CFF) TO HOLD-KEY-1
253400        MOVE F07803 (CFF) TO HOLD-KEY-2
253500        PERFORM C-F-ACCESS THRU END-ACCESS
253600        IF FOUND-WORD = '1'
253700        ADD 1 TO CAUSE-492 (I)
253800        ADD 1 TO G-CAUSE (I)
253900     DISPLAY 'I = ' I  '  CAUSE-492 = '  CAUSE-492 (I)
254000        IF F0800101B (3,1,1) NOT = ZERO
254100           ADD 1 TO G-CAUSE-FAT (I)
254200           ADD 1 TO CAUSE-FATAL (I) ELSE
254300           ADD 1 TO G-CAUSE-NONFAT (I)
254400           ADD 1 TO CAUSE-NON-FAT (I).
254500 PRE-END-CF.
254600     MOVE '0' TO FOUND-WORD.
254700     ADD 1 TO CFF.
254800 END-CF-SEARCH.  EXIT.
254900
255000 C-F-ACCESS.
255100     MOVE ZERO TO LO.
255200     MOVE HISAVE  TO HI.
255300 AD. COMPUTE I = (HI + LO) / 2.
255400     IF HOLD-KEY LESS THAN CAUSE-FACTOR-02R (I)
255500        MOVE I TO HI
255600        GO TO DZ.
255700     IF HOLD-KEY GREATER THAN CAUSE-FACTOR-02R (I)
255800        MOVE I TO LO
255900        GO TO DZ.
256000     MOVE '1' TO FOUND-WORD.
256100     GO TO END-ACCESS.
256200 DZ. IF 1 LESS THAN (HI - LO) GO TO AD.
256300 END-ACCESS. EXIT.
256400******** SEARCH FATAL CAUSE FOR TWO OR FOUR LARGEST TOTALS
256500*
256600 SEARCH-FACTOR.
256700     PERFORM SEARCH-SUB THRU END-SUB C-SV-LIMIT TIMES.
256800     MOVE 1 TO C-SV.
256900     MOVE 1 TO C-TEST.
257000*
257100******** OBTAIN THE ENGLISH MEANING HEADERS FOR A FACTOR
257200*
257300 WRITE-FACTOR.
257400     MOVE SPACES TO CAUSE-FACTOR-5.
257500     MOVE ZERO TO CF-FATALS CF-NONFAT.
257600     MOVE '1' TO READER-SWITCH.
257700     MOVE SPACES TO HD-KEY.
257800     MOVE 061766 TO CCC.
257900     IF C-SAVE-02 (C-SV) = ZERO
258000        GO TO WRITE-FACTOR-TOTALS.
258100     MOVE C-SAVE-02 (C-SV) TO C-SAVE.
258200     IF NOT (CAUSE-FATAL (C-SAVE) = ZERO AND
258300        CAUSE-NON-FAT (C-SAVE) = ZERO)
258400        MOVE CAUSE-FACTOR-02R (C-SAVE) TO CODE4
258500        PERFORM READER THRU REXIT
258600        MOVE CAUSE-FATAL (C-SAVE) TO CF-FATALS
258700        MOVE CAUSE-NON-FAT (C-SAVE) TO CF-NONFAT
258800        MOVE HDER TO CAUSE-FACTOR-5.
258900*
259000******** WRITE FACTOR TOTALS
259100*
```

```
WRITE-FACTOR-TOTALS.
    MOVE C-SV TO CF-NO.
    MOVE PAGE-5 (4) TO P-WORK-028.
    WRITE P-REC FROM P-WORK      AFTER POSITIONING 2.
    ADD 1 TO C-SV.
    IF C-SV GREATER THAN C-SV-LIMIT
        MOVE 1 TO C-SV
        GO TO END-FACTOR.
    GO TO WRITE-FACTOR.
END-FACTOR.      EXIT.
SEARCH-SUB.
    MOVE '0' TO FOUND-WORD.
    MOVE C-INITIAL TO F.
    MOVE ZERO TO C-SV.
    ADD 1 TO C-SAVE.
    MOVE CAUSE-FACTOR-02R (C-INITIAL) TO CAUSE-FACTOR-HOLD.
    MOVE FACTOR-02 TO FACTOR-77.
    MOVE CAUSE-492 (C-INITIAL) TO CAUSE-FACTOR-77.
    PERFORM SEARCH-SUB-A THRU END-SEARCH-A
        UNTIL FACTOR-02 NOT = FACTOR-77 OR F GREATER THAN 487.
    DISPLAY ' C-SAVE-02-CF = ' C-SAVE-01.
END-SUB.      EXIT.
SEARCH-SUB-A.
    MOVE CAUSE-FACTOR-02R (F) TO CAUSE-FACTOR-HOLD.
    IF FACTOR-02 NOT = FACTOR-77 GO TO END-SEARCH-A.
    IF CAUSE-492 (F) GREATER THAN CAUSE-FACTOR-77 OR =
                                  CAUSE-FACTOR-77
        MOVE ZERO TO C-SV
        PERFORM EXAM-SUB-F THRU END-EXAM
        IF FOUND-WORD = '1'
            MOVE '0' TO FOUND-WORD
                      ELSE
            MOVE F TO C-SAVE-02 (C-SAVE)
            MOVE CAUSE-492 (F) TO CAUSE-FACTOR-77.
    ADD 1 TO F.
    MOVE F TO C-HI.
END-SEARCH-A.      EXIT.
EXAM-SUB-F.
    ADD 1 TO C-SV.
    IF C-SV GREATER THAN C-SV-LIMIT GO TO END-EXAM.
    IF C-SAVE-02 (C-SV) = F
        MOVE '1' TO FOUND-WORD
        GO TO END-EXAM.
    GO TO EXAM-SUB-F.
END-EXAM.      EXIT.
PAGE-1-P.
    ADD 1 TO D.
    MOVE PAGE-1 (D) TO P-WORK-028.
    WRITE P-REC FROM P-WORK      AFTER POSITIONING 1.
    IF NOT (D = 11 OR 13 OR 15)
        WRITE P-REC  FROM SPACE-LINE AFTER POSITIONING 1.
END-PG-1.   EXIT.
PAGE-2-P.
    ADD 1 TO D.
    MOVE PAGE-2 (D) TO P-WORK-028.
    WRITE P-REC FROM P-WORK      AFTER POSITIONING 1.
    IF D = 1 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 10 OR 12 OR 21 OR
        23 OR 25 OR 33
        WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
END-PG-2.   EXIT.
PAGE-3-P.
    ADD 1 TO D.
    IF D = 7
        MOVE AVG-ANGLE TO AVG-ANGLE-3
        MOVE ANGLE-15         TO F0-15
        MOVE ANGLE-30         TO F16-30
        MOVE ANGLE-45         TO F31-45
        MOVE ANGLE-60         TO F46-60
        MOVE ANGLE-75         TO F61-75
        MOVE ANGLE-90         TO F76-90
        MOVE ANGLE-90-PLUS    TO F90.
    IF D = 13
        MOVE AVG-VEL TO AVG-ANGLE-3
```

```
               MOVE  VEL-30              TO F0-15
               MOVE  VEL-60              TO F16-30
               MOVE  VEL-90              TO F31-45
               MOVE  VEL-120             TO F46-60
               MOVE  VEL-120-PLUS        TO F61-75
               MOVE  ZERO TO F76-90 F90
               MOVE  PAGE-3 (7) TO P-WORK-02B
               WRITE P-REC FROM P-WORK        AFTER POSITIONING 1
          WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
          IF D = 18
               MOVE  AVG-DIST            TO AVG-ANGLE-3
               MOVE  DIST-10             TO F0-15
               MOVE  DIST-20             TO F16-30
               MOVE  DIST-30             TO F31-45
               MOVE  DIST-40             TO F46-60
               MOVE  DIST-50             TO F61-75
               MOVE  DIST-60             TO F76-90
               MOVE  DIST-60-PLUS        TO F90
          MOVE PAGE-3 (7) TO P-WORK-02B
               WRITE P-REC FROM P-WORK        AFTER POSITIONING 1
          WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
          MOVE PAGE-3 (D) TO P-WORK-02B.
          WRITE P-REC FROM P-WORK        AFTER POSITIONING 1.
          IF D = 7
          WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
          IF NOT (D = 4 OR 5 OR 10 OR 11 OR 15 OR 16 OR 19)
               WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
      END-PG-3.    EXIT.
      PAGE-4-P.
          ADD 1 TO D.
          MOVE PAGE-4 (D) TO P-WORK-02B.
          IF PAGE-4 (D) NOT  = SPACES
          WRITE P-REC FROM P-WORK        AFTER POSITIONING 1.
          IF NOT (D = 12 OR 13) AND PAGE-4 (D) NOT = SPACES
               WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 1.
      END-PG-4.    EXIT.
      SKIP-TO-HEAD.
          WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 0.
          WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 3.
          WRITE P-REC FROM SPACE-LINE AFTER POSITIONING 3.
          MOVE ZERO TO D.
      END-HEAD.    EXIT.
      BEGIN-SUB-SEARCH.
          MOVE ZERO TO FOUND-WORD.
          ADD 1 TO SSS.
          IF SAVE-SUB (SSS) = ZERO
               MOVE ZERO TO SSS
               GO TO END-SUB-SEARCH.
          IF OP = SAVE-SUB (SSS)
               MOVE '1' TO FOUND-WORD
               MOVE ZERO TO SSS
               GO TO END-SUB-SEARCH.
          GO TO BEGIN-SUB-SEARCH.
      END-SUB-SEARCH.      EXIT.
      LOAD-PG-3.
          SET SER-IND TO S-INDEX.
          MOVE SPACES TO PAGE-3-03I (SER-IND).
          MOVE S (S-INDEX,          SERIOUS-INDEX) TO SEV-FAT (SER-IND).
          MOVE S (S-INDEX,          SERIOUS-INDEX + 1) TO
               SEV-SER (SER-IND).
          MOVE S (S-INDEX,          SERIOUS-INDEX + 2) TO
               SEV-MIN (SER-IND).
          MOVE S (S-INDEX,          SERIOUS-INDEX + 3) TO
               SEV-NON (SER-IND).
      END-LOAD-3.    EXIT.
      LOAD-PG-4.
          MOVE SPACES TO HD-KEY.
          MOVE 042222 TO CCC.
          MOVE TERRAIN (TERRAIN-INDEX) TO CHAR1.
               MOVE '1' TO READER-SWITCH.
          PERFORM READER THRU REXIT.
          SET TER-IND TO TERRAIN-INDEX.
          MOVE SPACES TO PAGE-4-03H (TER-IND).
```

```
273800     MOVE HDER TO TERR-TYP (TER-IND).
273900     IF TOT-AC-TYPE NOT = ZERO
274000     DIVIDE TERRAIN-COUNT (TER-IND) BY TOT-AC-TYPE GIVING
274100         PCNT-OCC ROUNDED ELSE MOVE ZERO TO PCNT-OCC.
274200     MULTIPLY PCNT-OCC BY 100 GIVING PCNTT.
274300     MOVE PCNTT     TO PCT-TER  (TER-IND).
274400     MOVE ZERO TO PCNT-OCC PCNTT.
274500 END-LOAD-4.      EXIT.
274600 SORT-PG-4.
274700     IF ITER-4 GREATER THAN 13
274800         MOVE PAGE-4-WORK TO PAGE-4-03GROUP
274900         GO TO END-SORT.
275000     ADD 1 TO TER-IND.
275100     IF TER-IND GREATER THAN 13
275110         MOVE PCT-TER (1) TO PCT-HOLD
275200         ADD 1 TO ITER-4
275300         MOVE ZERO TO TER-IND
275400         MOVE SPACES TO PAGE-4-03H (INDEX-HOLD)
275500         GO TO SORT-PG-4.
275600     IF PCT-TER (TER-IND) = ZERO OR SPACES
275700         MOVE SPACES TO PAGE-4-03H (TER-IND).
275800     IF PCT-TER (TER-IND) GREATER THAN PCT-HOLD OR
275810         PCT-TER (TER-IND) = PCT-HOLD
275900         MOVE PAGE-4-03H (TER-IND) TO PAGE-4-W02 (ITER-4)
276000         MOVE TER-IND TO INDEX-HOLD
276100         MOVE PCT-TER (TER-IND) TO PCT-HOLD.
276200     GO TO SORT-PG-4.
276300 END-SORT.   EXIT.
276400 INITIALIZE-COUNTERS.
276500     MOVE ZERO TO
276600     J                TOT-AC           TOT-OCC          AV-OCC
276700     TOT-FAT          TOT-SER          TOT-MNR          TOT-NON
276800     REC-TOT-OCC      HEAD-COUNT       S-H-INSTALLED    S-H-USED
276900     S-H-FAILED       HELMET-USED      HELMET-UNUSED    TOT-ST-ACC
277000     TOT-ST-FAIL      VEL-30           VEL-60           VEL-90
277100     VEL-120          VEL-120-PLUS     TOT-ACC-VEL      VEL-SUM
277200     AVG-VEL          DIST-10          DIST-20          DIST-30
277300     DIST-40          DIST-50          DIST-60          DIST-60-PLUS
277400     TOT-ACC-DIST     DIST-SUM         AVG-DIST         TOT-STBLT-ACC
277500     TOT-STBLT-FAIL   ANGLE-15         ANGLE-30         ANGLE-45
277600     ANGLE-60         ANGLE-75         ANGLE-90         ANGLE-90-PLUS
277700     TOT-ACC-ANG      ANGLE-SUM        AVG-ANGLE        TOT-T-O
277800     TOT-FLY          TOT-LDG          UP               UP-PH-TOT
277900     TYP-TOT-01       CAUSE-01         CAUSE-FATAL-01   FAT-TO
278000     CAUSE-NONFAT-01 PG-1-SERIOUS-01 FAT-INFLT        FAT-LOG
278100     TOT-ST-ACC       TOT-ST-FAIL      TERRAIN-001      SERIOUSNESS
278200     TOT-NR           TOT-TS           FAT-TS           FAT-NR
278300     F                INJ-01           C-SAVE 01        TOT-AC-TYPE
278310     TALLY.
278400     MOVE SPACES TO SAV-CARD.
278500     MOVE 1 TO D.
278600 END-INITIALIZE.      EXIT.
```

A.6 SAMPLE INPUT

```
BLOCK  98  DATA  1600     0731693 C057Y8407R    011069NREDDING,CALIF    PIPER      PA-28          2145 A05124281206AAA1ADYA D
                          80   MID9                                      08FZ3 YN
                          FA  AA   A  CA   A  A                                     02000AR  A 00219A          ZA      25A
                                                  F  1           6443364A0464466B2JA
                                                                   1
                            1         2           2                                                               1
                          LT.FOLLOWED              HWY INTO VALLEY WITH LOW CLOUDS.NOT INST RATED.  P RECOVERY DATE-1/13/69.LOST ON NITE F
                                                                              2              F014C0GL 8103       039
                          B         B 002          X               D2                  AX                            AKFH  C609
                                                                                                  GAF

BLOCK  99  DATA  1609     0731693 0011N8126Y    010469 TOUGHKENAMON,PA  PIPER      PA-30           1150 A38124291232AAA2AS   F
                          81   A EFF FF             CLEMENTON AVIA         BA  A  A     FN GARDEN        03435C        02933
                          CA  AA   A  BA  AA  A                    64C2264L3164L0889K94       A 00278A    00011A        51A
                                                  N           1    1
                                              1      1
                          ERTED VISION             FROM RNWY TO INST PANEL TO LOCATE FLAP CONTROL.  P THIRD SOLO FLT IN MULTI-ENG ACFT.DIV
                                                                        000675            2013301L JB        026293038
                                                                     01    023
                                                                                                  GAF

BL(  100  DATA  1600      0731695 0001DYDSG     011569 NORTHBROOK,ILL   PIPER      PA-30           1610 F131242912364AA235   F
                          80   A EFNCEF              GS FLYVESKOL          8A  I  4     FSKY HARBOR      00680AC  D C02403
                          AA  PA   A  GA  GA  A                    64C7980LBC                A 06000A     00007A        32A
                                                  N           1    1
                            1                   2       2                                                            1

                                                                        000446            F01000EK 89          130010
                                                                     02    103
                                                                                                  GAF

BLOCK  101  DATA  1600    1009693 C031N5564J    021069 DALLAS,TEX       PIPER      PA-32           2225 A43124301236AAA1AS   E
                          CJ   FN7B1F 91             TRICON INTL AL        DA  A  A     FLOVE FIELD      03485A A    A07751
                          BA  MA   A  CA  GA  A                    84CJ 08K5463LH1               A 01118A     00013A        23A
                                                  N           1    1
                                              1      1
                          A.                       PILOT-MISJUDGED EDGE OF TAXI RAMP.    P ACFT WENT DOWN INTO DRAINAGE PIT ARE
                                                                        000377              A    UIL J               115009
                                                                  015404    445
                                                                                                  GAF
```

A.7 SAMPLE OUTPUT

Typical individual airplane output data is shown in Figures 12 and 13. Typical grand summary data output is shown in Figure 13. Both Figures are contained in this report on pages 42 through 47.

A.8 DISCUSSION OF PROGRAM AND DATA TAPE

Data Processing Information

This tape is 9 track, unlabeled, blocked 3440 with 80 by 6 record length.

Tape layout

The content of this tape is as follows

Program MTSB0001
*****
Program MTSB0002
*****
Program 1325020D
*****
NTSB record used in MTSB0001 and MTSB0002
*****
Full Print Headers
*****
Job Control to catalog and execute the system

The jobs are separated by one record with five (5) asterisks in column 1-5. The tape was tested at Cessna by selection and printing 1325020D and the job control and not the remainder.

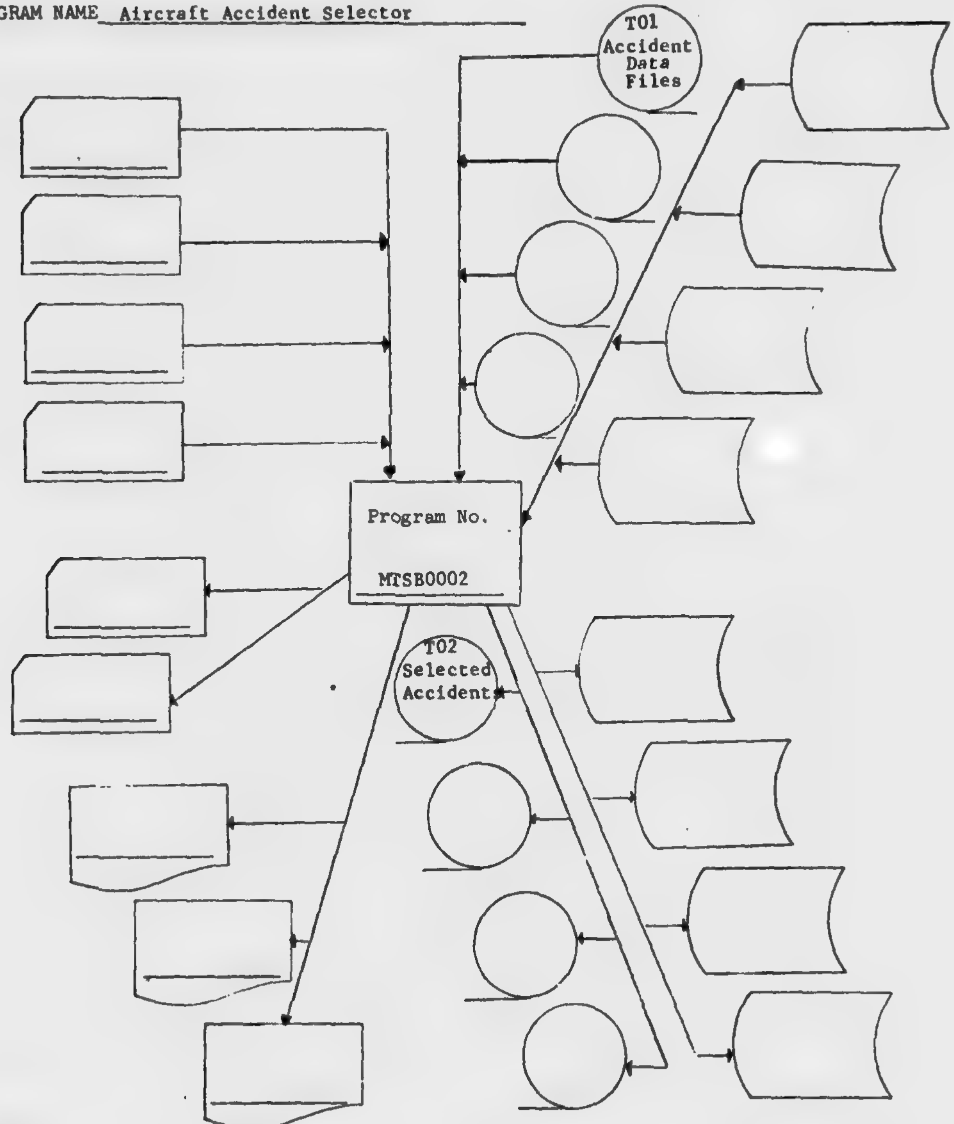
A.9 MACHINE ROOM SET-UP SHEETS

Summary of Three NTSB Accident Data Files

1. MTSB0002 - Aircraft Accident Selector
2. SORT - Sort Accidents
3. 1325020D - Create English Meaning Headers Direct Access File
4. MTSB0001 - Additional Selection and Summarization of Selected Accidents

```
**************************************************************************
*                                                                        *
*                   T O T A L   R E Q U I R E M E N T S                  *
*                                                                        *
*   I-O                                                                  *
*                                                                        *
*   Reader                                                               *
*   Printer                                                              *
*   Tape Drives - 3                                                      *
*   Disk Drives - 2 (1 if 3800 Tracks are Available on Single Drive)     *
*                                                                        *
*                                                                        *
*   Core                                                                 *
*           92K                                                          *
*                                                                        *
**************************************************************************
```

PROGRAM NAME Aircraft Accident Selector



Files:

Sys No.	File Serial	File Name	Disposition
001	N/A	Accident Data Files	Store
002	N/A	Selected Accidents	To Sort

PRINTER SET-UP

Carriage Tape 88 Lines/Page

Vertical Alignment Upper Most

Horizontal Alignment Left

Paper size or form number:

14 x 11 1 Part

	Name	Disposition
Cards In:		
Cards Out: P1		
P2		
RP3		

CAN JOB BE RESTARTED? ( ) YES (X) NO

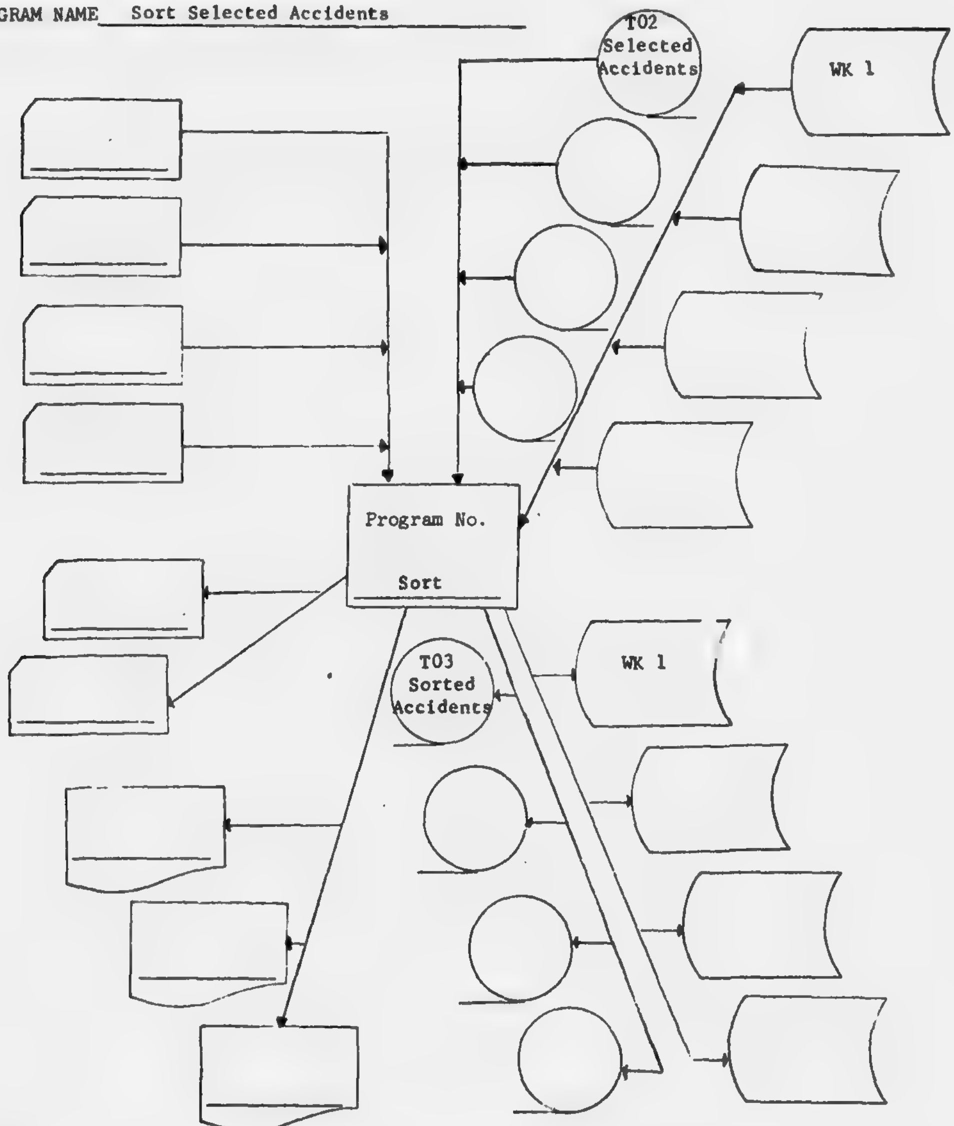
CAN JOB BE RERUN? (X) YES ( ) NO

If no, see special instructions for appropriate action.

CONSOLE MESSAGE:	ACTION
1. N/A	
2.	
3.	
4.	
5.	

Special Instructions:

PROGRAM NAME Sort Selected Accidents



Files:

Sys No.	File Serial	File Name	Disposition
N/A	N/A	N/A	N/A

PRINTER SET-UP

Carriage Tape ______________ [illegible]

Vertical Alignment ______________ ______________

Horizontal Alignment ______________ ______________

	Name	[illegible]
Cards In:		
Cards Out: P1		
P2		
RP3		

CAN JOB BE RESTARTED? ◯ YES (X) NO

CAN JOB BE RERUN? (X) YES ◯ NO

If no, see special instructions for appropriate action.

CONSOLE MESSAGE:	ACTION
1. See User's Manual	
2.	
3.	
4.	
5.	

Special Instructions:

____

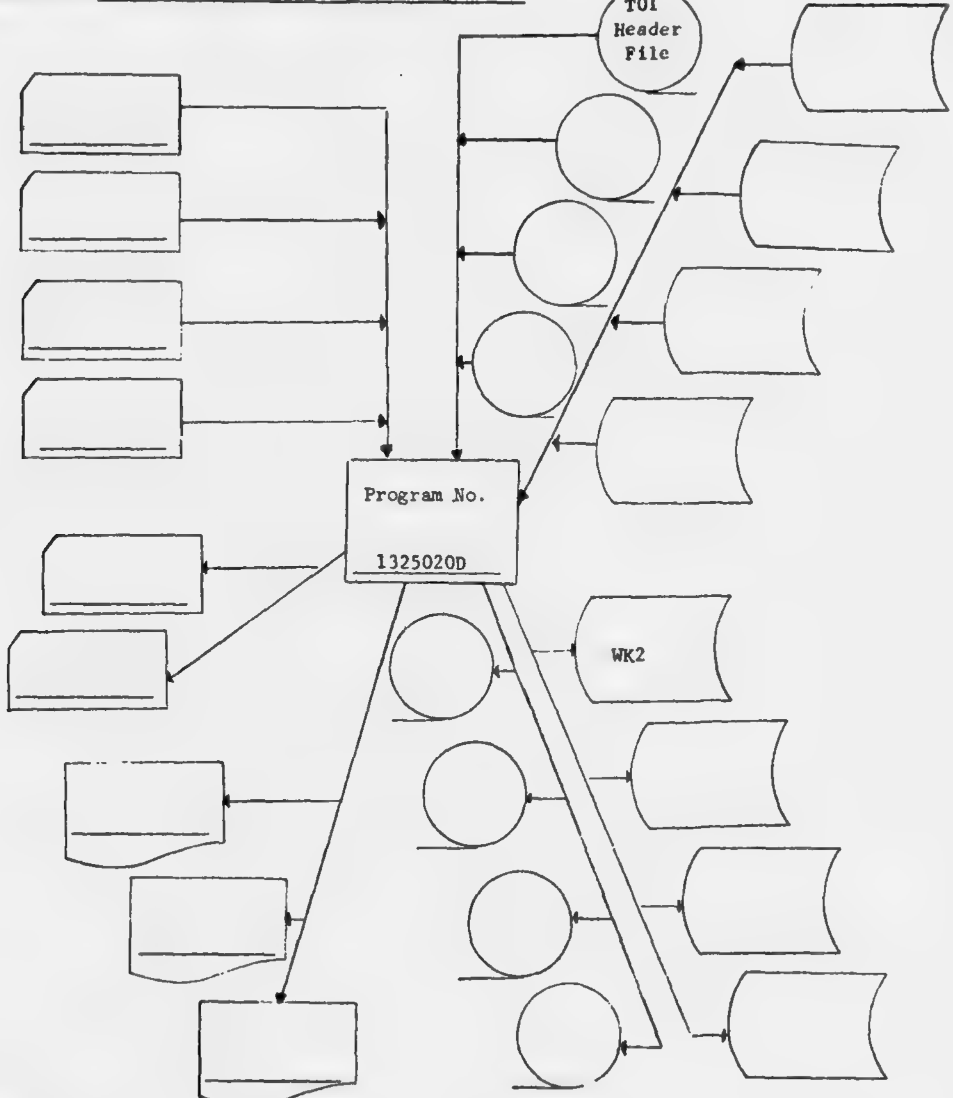
____

____

____

____

PROGRAM NAME Load English Meaning Headers



Files:

Sys No.	File Serial	File Name	Disposition
010	325020	NTSB Headers	Store

PRINTER SET-UP

Carriage Tape ____________________ Paper size or Form number

Vertical Alignment ____________________ ____________________

Horizontal Alignment ____________________ ____________________

	Name	Disposition
Cards In:		
Cards Out: P1		
P2		
RP3		

CAN JOB BE RESTARTED? ◯ YES (X) NO

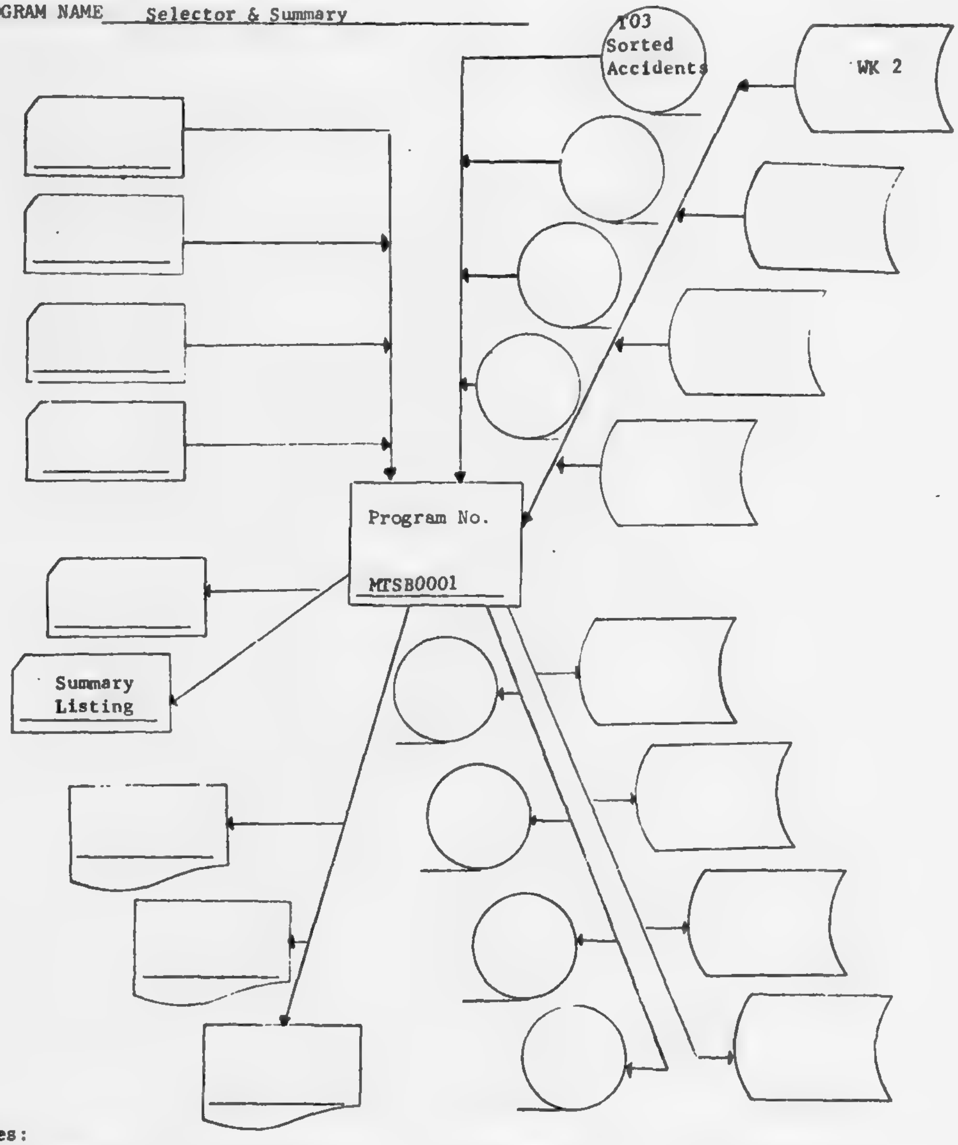
CAN JOB BE RERUN? (X) YES ◯ NO

If no, see special instructions for appropriate action.

CONSOLE MESSAGE:	ACTION
1.	
2.	
3.	
4.	
5.	

Special Instructions:

PROGRAM NAME Selector & Summary



Files:

Sys No.	File Serial	File Name	Disposition
018	N/A	N/A	Store or Recycle
019	N/A	NTSB	N/A

PRINTER SET-UP

Carriage Tape 88 Lines/Page

Vertical Alignment Upper Most

Horizontal Alignment Left

Paper size or form number:

14 x 11 1 Part

	Name	Disposition
Cards In:	N/A	
Cards Out: P1	N/A	
P2		
RP3		

CAN JOB BE RESTARTED? ◯ YES (X) NO

CAN JOB BE RERUN? (X) YES ◯ NO

If no, see special instructions for appropriate action.

CONSOLE MESSAGE:	ACTION
1.	
2.	
3.	
4.	
5.	

Special Instructions:

APPENDIX B

REPRESENTATIVE GENERAL AVIATION AIRPLANE STRUCTURE

B.1 INTRODUCTION

This appendix describes the structure that is representative of two different types of general aviation light fixed-wing airplanes. In addition typical cross sections, from which basic area properties (A, I_{yy}, I_{zz}) are obtained, are shown. The structure material properties (E, G), combined with the area properties, are used to determine member stiffnesses.

B.2 AIRPLANE A

Airplane A is a category 1 type of airplane with the following general description:

- Single-engine, high-wing configuration
- Side by side seats (two occupants)
- Used for training, sport or aerobatic purposes
- Stall speed (flaps down) $\leq$ 42 knots
- Cruise speed (75% power) $\leq$ 102 knots
- Flight design load factor of; +4.4g's and -1.76g's (utility)
+6.0g's and -3.00g's (aerobatic)
- Maximum takeoff weight = 1600 pounds
- Wing span = 384 inches
- Length = 280 inches

Figure B-1a shows an overall view of the airplane and Figure B-1b shows the mathematical model used to represent the structure for crash analysis.

Figures B-2 through B-12 show different structures and approximate cross sections for the respective structure. Table B-1 describes the Airplane A Structure with regard to material properties, strength, design concepts, size and attachments.

B.3 AIRPLANE B

Airplane B is a category 3 type airplane with the following general description:

- Single engine low wing configuration
- Single seat
- Used for application of chemicals or seeding crops
- Stall speed (flaps down) $\leq$ 50 knots
- Cruise speed (75% power) $\leq$ 122 knots
- Flight design load factor of; +3.8g's and -1.52g's
- Maximum takeoff weight = 3300 pounds (4000 pounds in restricted category)
- Wing span = 474 inches
- Length = 273 inches

Figure B-13a shows an overall view of the airplane and Figure 13b shows the mathematical model used to represent the structure for crash analysis. Figures B-14 through B-20 show different structure and approximate cross sections used to represent the structure. Table B-2 describes the airplane B structure with regard to material properties, strength, design concept, size and attachments. Table B-3 presents the cross sectional dimensions of the fuselage tubular framework.

TABLE B-1 DESCRIPTION OF AIRPLANE A STRUCTURE

Structure	Materials and Properties	Concepts and Size	Attachments	Applicable Figures
1. Engine Mount Assembly and Nose Landing Gear	4130 Steel $E = 30 \times 10^6$ psi $G = 11 \times 10^6$ psi $F_{ty} = 75 \times 10^3$ psi $F_{tu} = 95 \times 10^3$ psi	Tubular members .75 in. x .049 in. .50 in. x .049 in. Hydraulic cylinder nose gear	Bolt attachments to fire wall, 4 places, to engine 4 places.	B-2
2. Main Landing Gear	6150H Steel $E = 30 \times 10^6$ psi $G = 11 \times 10^6$ psi $F_{ty} = 205 \times 10^3$ psi $F_{tu} = 245 \times 10^3$ psi	Flat steel spring. Tapered cross section. Average cross section are shown in Figure B-3	Single bolt attachment inboard to fuselage	B-3
3. Landing Gear Bulkhead	2024-T3 $E = 10.5 \times 10^6$ psi $G = 4 \times 10^6$ psi $F_{ty} = 37 \times 10^3$ psi $F_{tu} = 63 \times 10^3$ psi	Two formed bulkheads with skin attachment above and below. Dimensions are shown in Figure B-5	Landing gear forgings attached between bulkheads by means of bolts	B-4, B-5
4. Firewall	Stainless Steel $E = 27 \times 10^6$ psi $G = 11 \times 10^3$ psi $F = 58 \times 10^3$ psi (avg. of F_{ty} and F_{tc}) $F_{tu} = 124 \times 10^3$ psi	Beaded flat aluminized iron sheet, a peripheral stiffener and attaching fuselage skin. Thickness = .025 in.	Steel rivets	B-4, B-5
5. Upper and Lower Engine Mount Stringer	2043-T3 Aluminum $E = 10.5 \times 10^6$ $G = 4. \times 10^6$ psi $F_{ty} = 37 \times 10^3$ psi $F_{tu} = 63 \times 10^3$ psi	Upper mount stringer is a tapered U channel section. Average section shown in Figure B-5, Lower Mount Stringer is a Channel with J edges, as shown in Figure B-5	Rivets	B-4, B-5

TABLE B-1 DESCRIPTION OF AIRPLANE A STRUCTURE (Cont'd)

Structure	Materials and Properties	Concepts and Size	Attachments	Applicable Figures
6. Upper Cabin Area	Same as No. 5	This area is comprised of a root rib-upper door jam, cabin top skin and two stringers. It extends from the forward door post to aft door post. Dimensions are shown in Figure B-5.	Rivets	B-4, B-5
7. Forward Floor Bulkhead	Same as No. 5	Consists of formed bulkhead stiffener on aft side, floor-board on top and skin on bottom. Average cross section, as shown in Figure B-7.	Rivets	B-6, B-7
8. Forward Door Post	Same as No. 5	Assemblage of three pieces, as shown in Figure B-7. Maximum cross-section is shown.	Rivets, screws and bolts	B-6, B-7
9. Fuselage Carry thru Structure	Same as No. 5	Formed channels, same dimension front and rear. Approximate dimensions are shown in Figure B-7	Rivets and bolts	B-6, B-7
10. Rear Door Post	Same as No. 5	Assemblage of three pieces, doorpost, jam and skin. Dimensions along uniform length are shown in Figure B-9.	Rivets, screws and bolts	B-8, B-9
11. Upper and Lower Aft Fuselage	Same as No.5	Upper sections consists of skin-stringer arrangement. Lower section is a semi-monocoque structure. Approximate dimensions are shown in Figure B-9	Rivets	B-8, B-9

TABLE B-1 DESCRIPTION OF AIRPLANE A STRUCTURE (Cont'd)

Structure	Materials and Properties	Concepts and Size	Attachments	Applicable Figures
12. Tail Cone	Same as No. 5	Tapered semi-monocoque section. Approximate average section is shown in Figure B-10	Rivets	B-8, B-10
13. Bulkhead at F.S. 95	Same as No. 5	Formed one piece sheet metal Bulb angle reinforce lower section. Approximate cross-section is shown in Figure B-10.	Bolts at wing attachment. Rivets at forward section.	B-8, B-10
14. Wing	6061-T6 $E = 10.5 \times 10^6$ psi $G = 4 \times 10^6$ psi $F_{ty} = 32 \times 10^3$ psi $F_{tu} = 38 \times 10^3$ psi	Two spar arrangement. Average cross section at constant chord line and for tapered expanse is used.	Bolted to strut and fuselage top	B-11, B-12
15. Wing Strut	Same as No. 14	Extruded tube Uniform cross section	Forged attachment fittings single bolted at each end of strut extrusion	B-11, B-12

F_{ty} = Tensile yield stress

F_{cy} = Compressive yield stress

F_{tu} = Tensile ultimate stress

E = Modulus of Elasticity
G = Modulus of Rigidity

LOCKHEED

TABLE B-2 DESCRIPTION OF AIRPLANE B STRUCTURE

Structure	Materials and Properties	Concepts and Size	Attachments	Applicable Figures
1. Fuselage	4130 Steel $E = 30 \times 10^6$ psi $G = 11 \times 10^6$ psi $F_{ty} = 75 \times 10^3$ psi $F_{tu} = 95 \times 10^3$ psi	Tubular members of various sizes. See Table B-3.	Pin joints (bolt through clevis) for strut ard wing attachments. Bolted joints for Firewall and tail cone attachments	B-14
2. Engine Mounts	4130 Steel $E = 30 \times 10^6$ psi $G = 11 \times 10^6$ psi $F_{ty} = 75 \times 10^3$ psi $F_{tu} = 95 \times 10^3$ psi	Tubular members: .75 inch x .049 inch .875 inch x .049 inch Arrangement and attachments are shown in Figure B-15	Bolted to firewall, 4 places. Isolator mounted to engine, 4 places	B-15
3. Wing Strut	2024-T3 Aluminum $E = 10.5 \times 10^6$ psi $G = 4.0 \times 10^6$ psi $F_{ty} = 37 \times 10^3$ psi $F_{tu} = 63 \times 10^3$ psi	Constant cross section See Figure B-12 for dimensions	Pin joints at fuselage and wing.	B-16
4. Wing	2024-T3 Aluminum $E = 10.5 \times 10^6$ psi $G = 4.0 \times 10^6$ psi $F_{ty} = 37 \times 10^3$ psi $F_{tu} = 63 \times 10^3$ psi	Two spar arrangement Rib spacing is approximately 26 inches. Skin thickness = .035 to .032 inches. Average dimensions are shown in Figure B-17.	Pin joint to the fuselage at front and rear spars	B-17
5. Landing Gear	6150 H Steel $E = 30 \times 10^6$ psi $G = 11 \times 10^6$ psi $F_{ty} = 205 \times 10^3$ psi $F_{tu} = 245 \times 10^3$ psi	Tapered spring. Average section = 4.5 inches wide. Spring provides all landing gear stiffness.	Four bolts at fuselage each side. One bolt to axle.	B-18

TABLE B-2 DESCRIPTION OF AIRPLANE B STRUCTURE (Cont'd)

Structure	Materials and Properties	Concepts and Size	Attachments	Applicable Figures
6. Vertical Tail	2024-T3 Aluminum $E = 10.5 \times 10^6$ psi $G = 4.0 \times 10^6$ psi $F_{ty} = 37 \times 10^3$ psi $F_{tu} = 63 \times 10^3$ psi	Front and rear spar Spar thickness = .040 inches. Shim thickness = .025 inches. Cross section is shown in Figure B-19	Bolt attachment at front and rear spars to tail cone	B-19
7. Fuselage Tailcone	2024-T3 Aluminum $E = 10.5 \times 10^6$ psi $G = 4.0 \times 10^6$ psi $F_{ty} = 37 \times 10^3$ psi $F_{tu} = 63 \times 10^3$ psi	Intermediate bulkheads, stiffened-shim arrangement. Thickness of skin, bulkhead and stiffener = .032 inches. Cross sections and attachments are shown in Figure B-20	Bolted to aft bulkhead, 4 places.	B-20

Notes:

F_{ty} = Tensile yield stress

F_{tu} = Tensile ultimate stress

E = Modulus of Elasticity

G = Modulus of Rigidity

TABLE B-3 AIRPLANE B FUSELAGE STRUCTURE
TUBULAR MEMBER SIZES

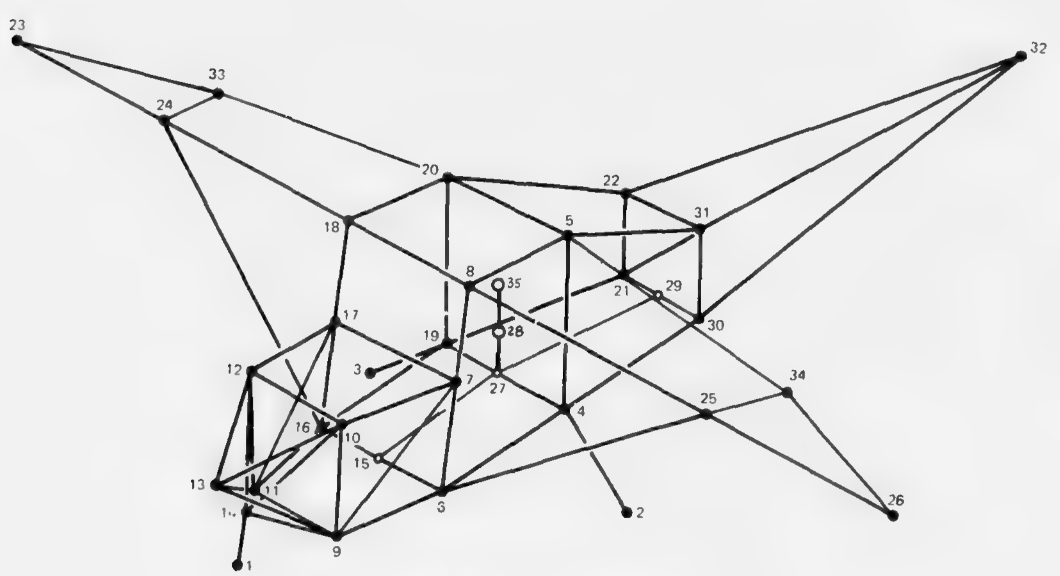
Member	i^{th} Node(a)	j^{th} Node(a)	Tube Size (diameter and thickness), Inches
8	22	32	.750 x .058
9	4	32	.875 x .049
10	32	33	.50 x .035
11	6	33	.875 x .049
12	23	33	1.125 x .049
13	27	33	1.375 x .083
14	5	6	1.375 x .058
15	4	5	.75 x .035
16	5	17	1.0 x .049
17	5	7	1.0 x .049
18	5	17	.625 x .035
19	6	8	1.0 x .049
20	6	18	1.25 x .049
21	6	26	.875 x .049
22	7	8	.875 x .049
23	7	9	1.00 x .065
24	7	37	1.5 x .058
25	24	26	1.0 x .049
26	25	27	1.0 x .049
27	8	10	.625 x .049
28	8	15	1.0 x .049

(a) See Figure B-13 for i^{th} and j^{th} node designations

(b) Tube sizes for left side are shown, right side has same dimensions

(c) Diagonal member sizes are 1.0 inch x .049 inch

(a) OVERALL VIEW



(b) MATH MODEL

Figure B-1. Airplane A

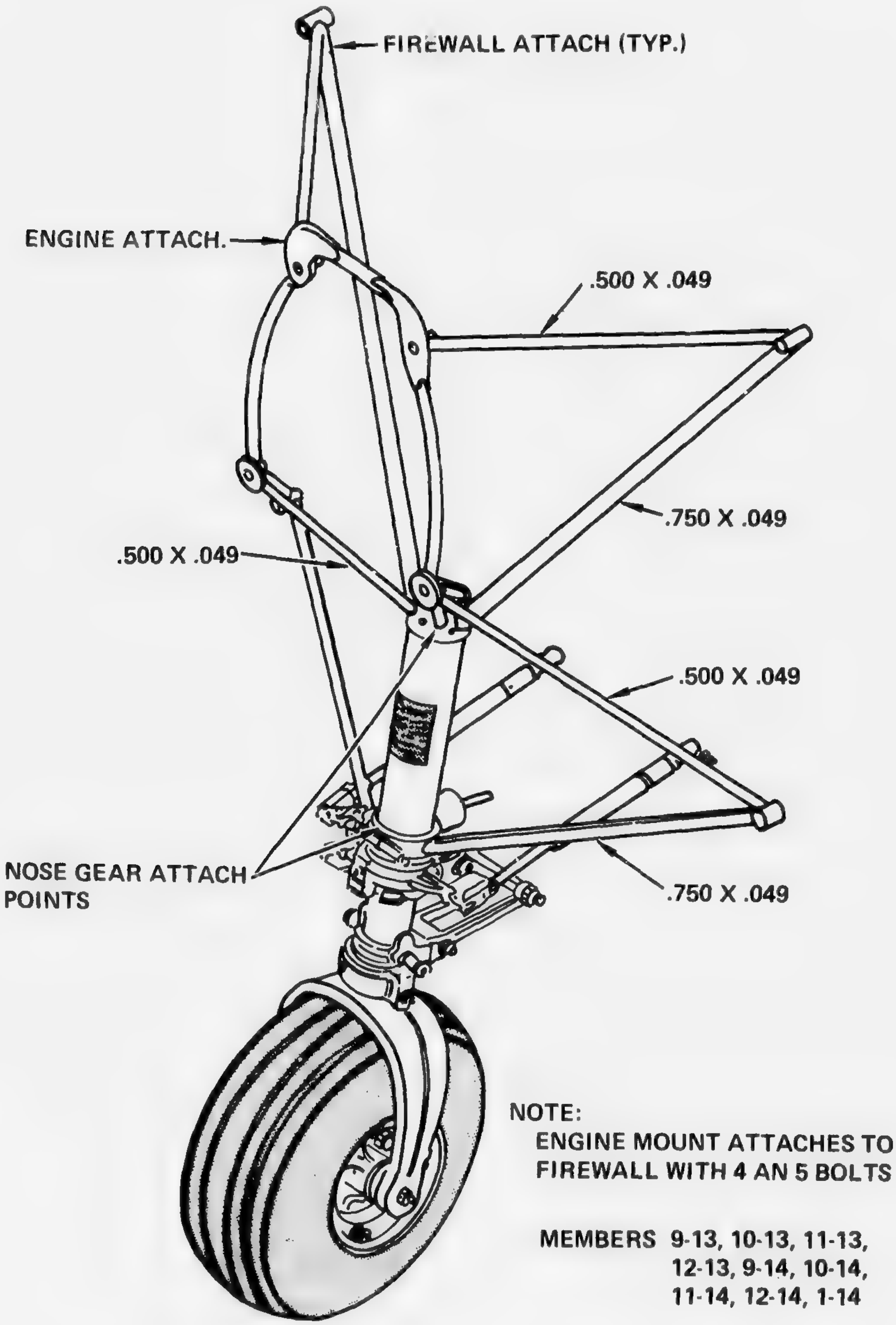


Figure B-2. Engine Mount and Nose Gear Assembly

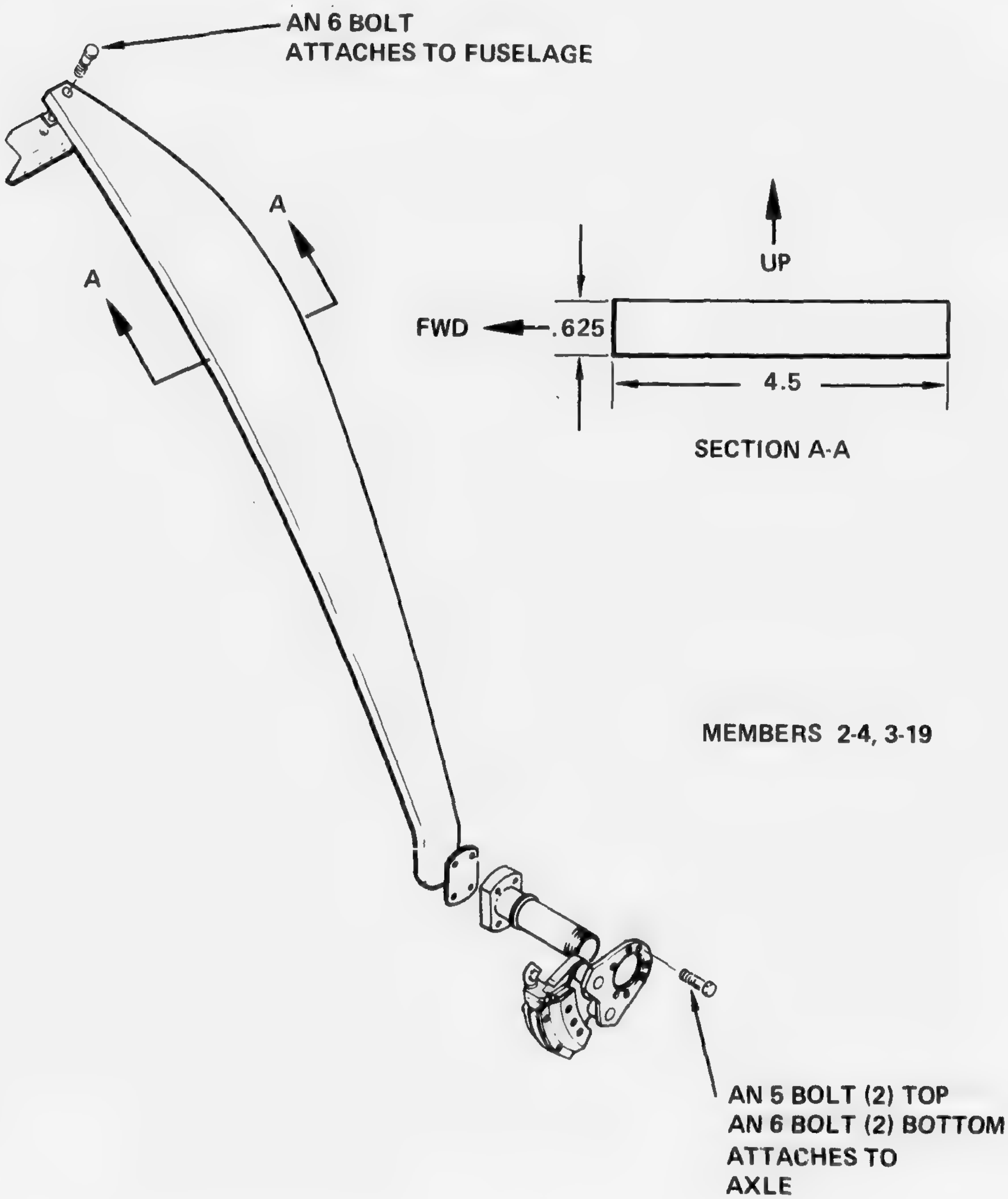


Figure B-3 Main Landing Gear Cantilever Spring Cross-Section

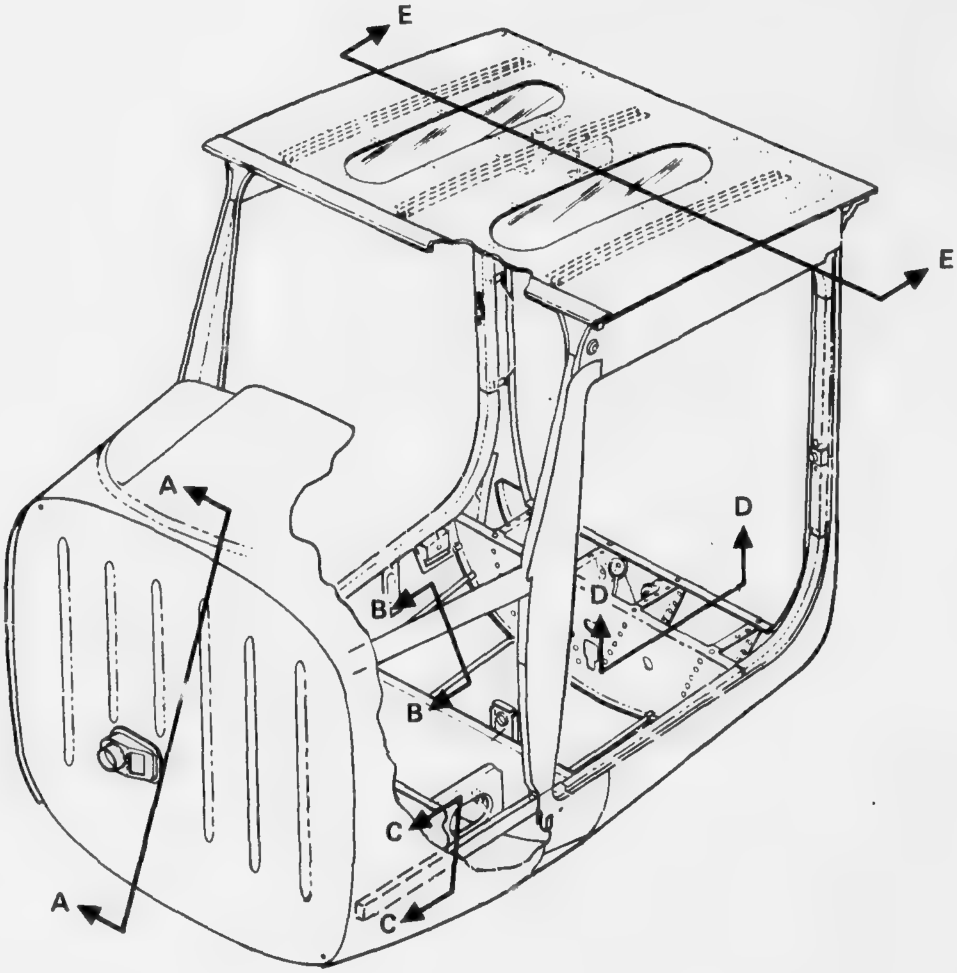


Figure B-4. Fuselage Front and Center Section Assembly

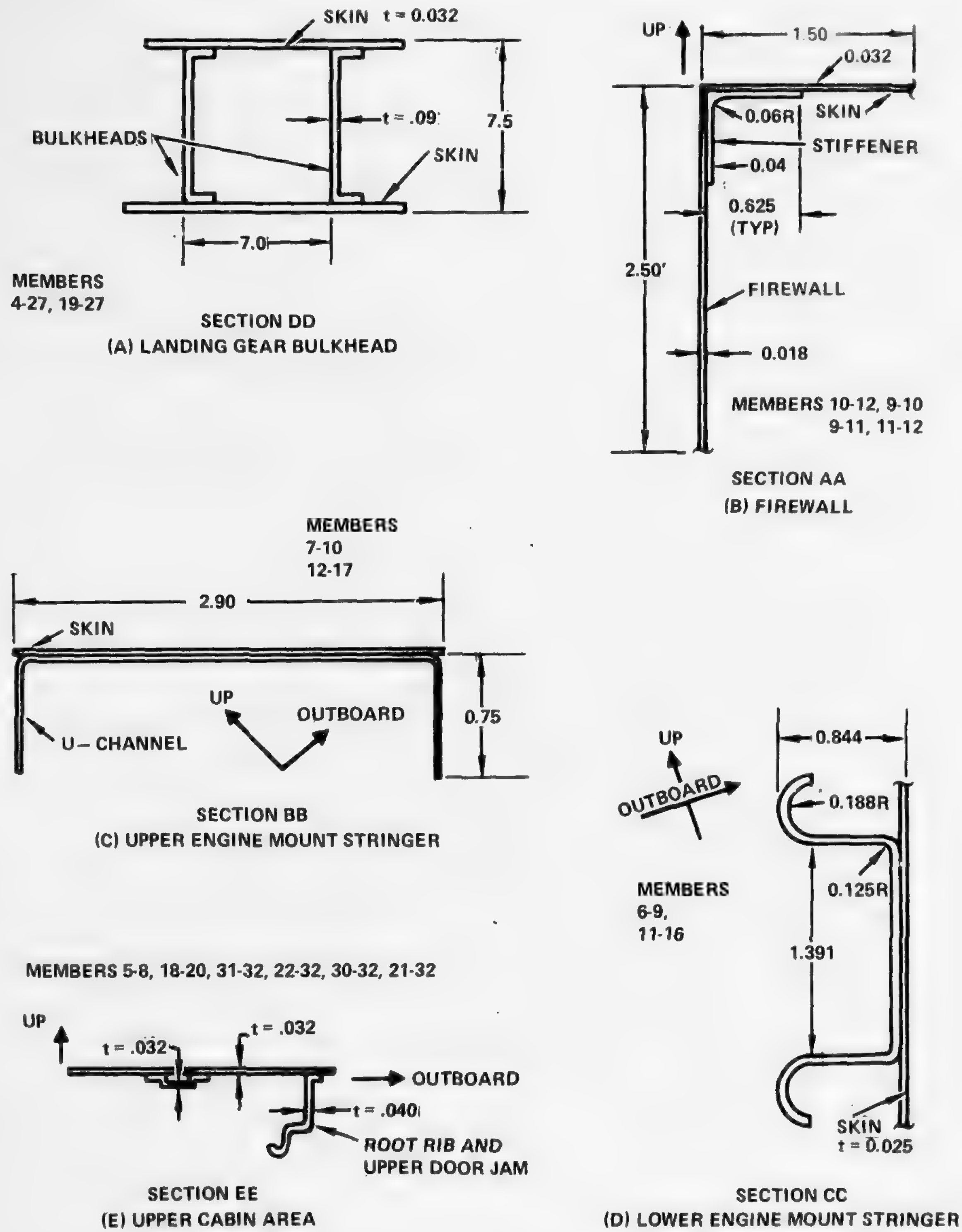


Figure B-5 Fuselage Front and Center Structure Cross Sections

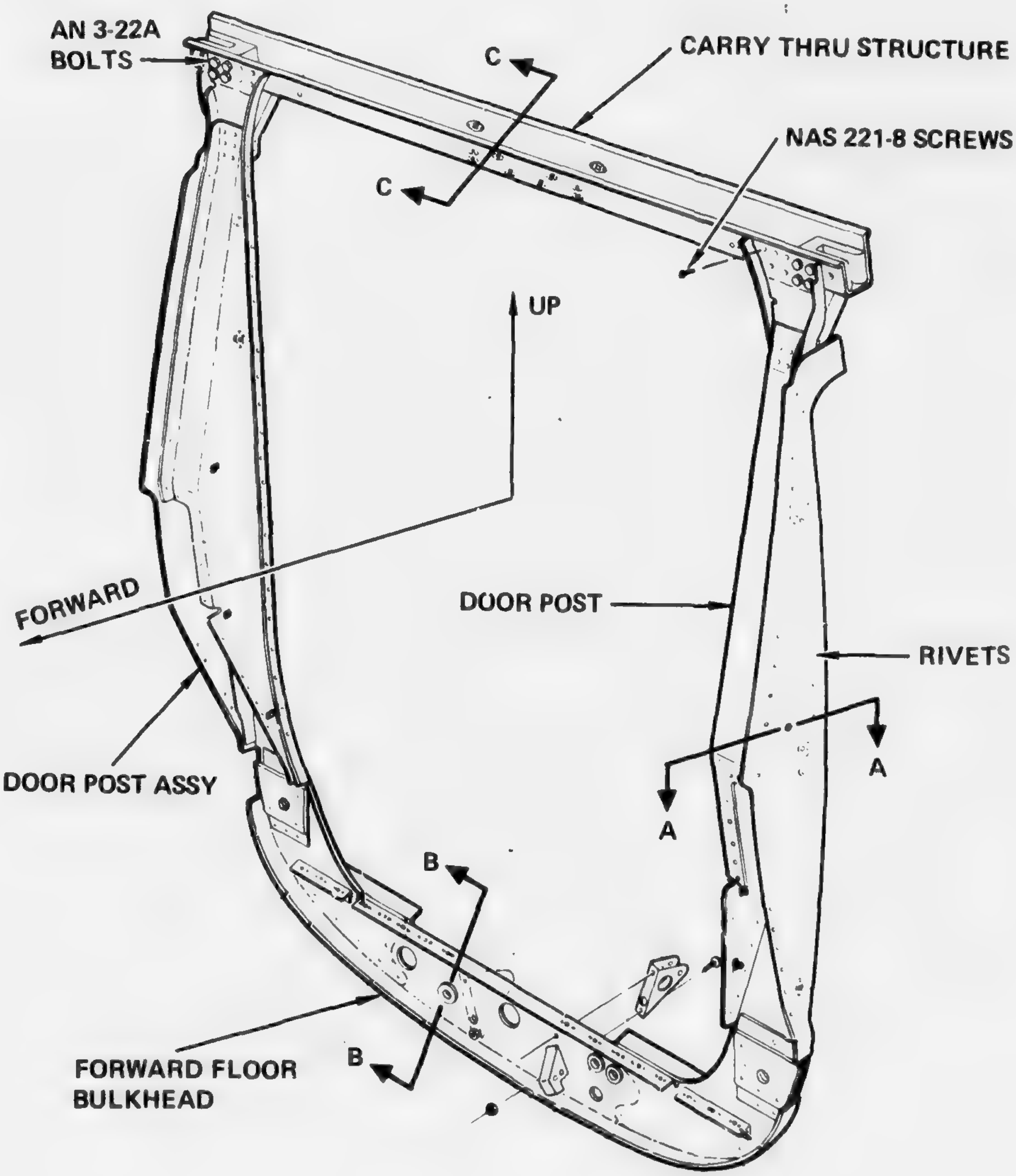


Figure B-6. Forward Door Post, Forward Floor Bulkhead, and Carry Thru Structure

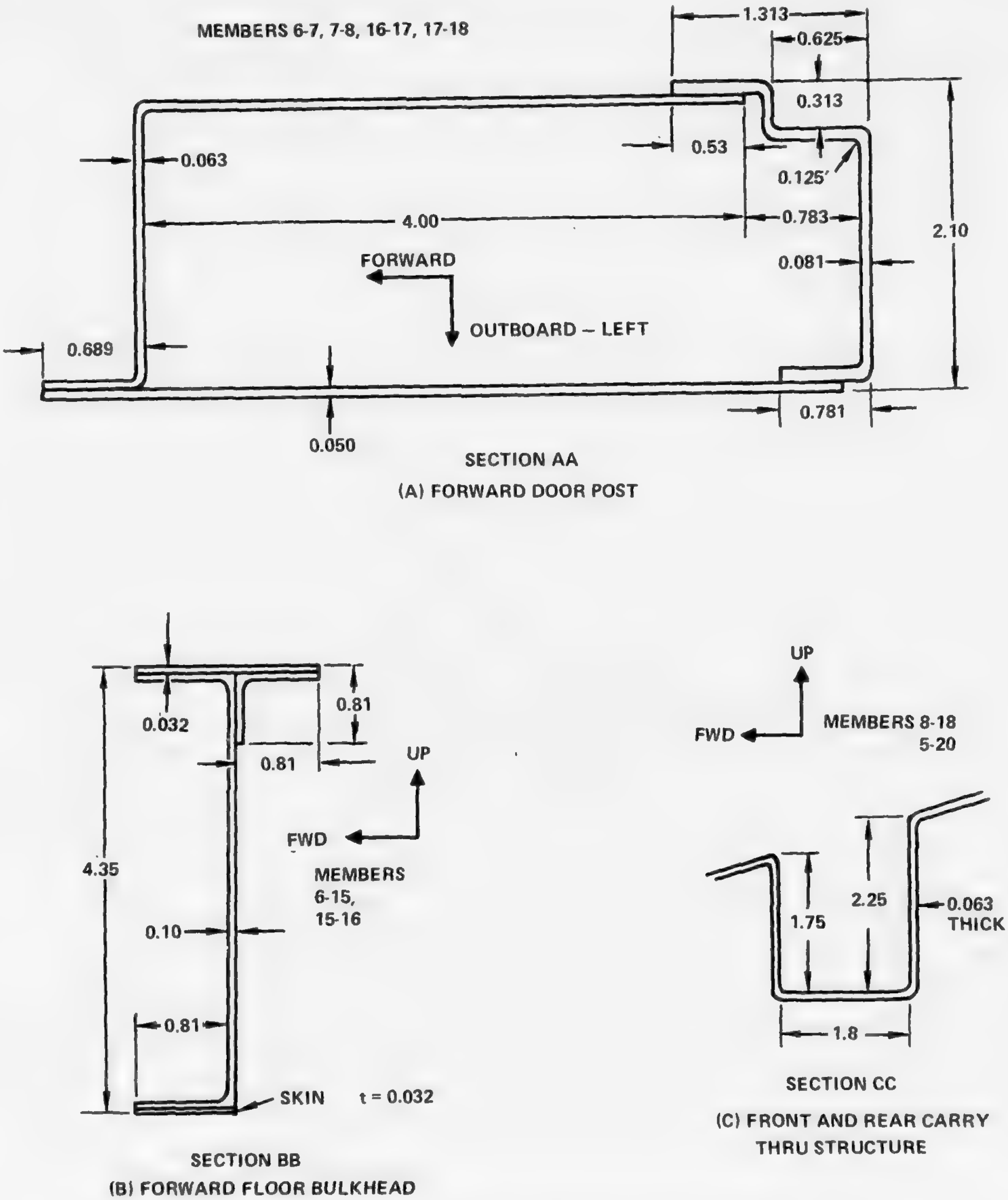


Figure B-7 Forward Door Post, Forward Floor Bulkhead, and Carry Thru Structure Cross Sections

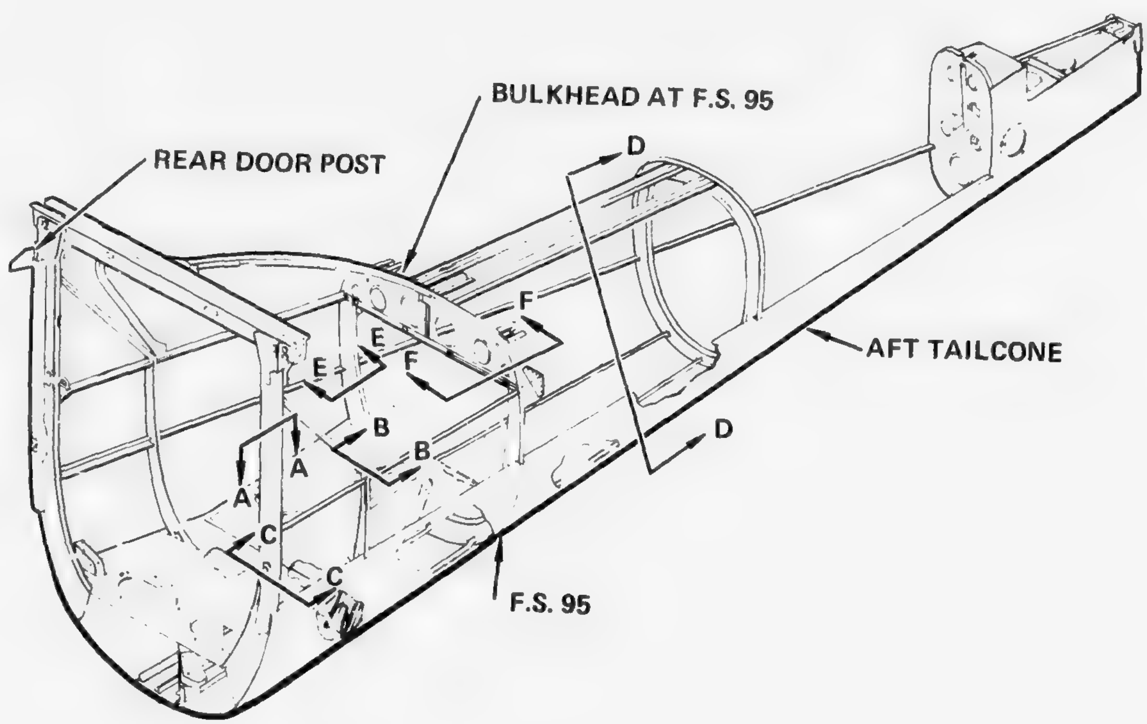
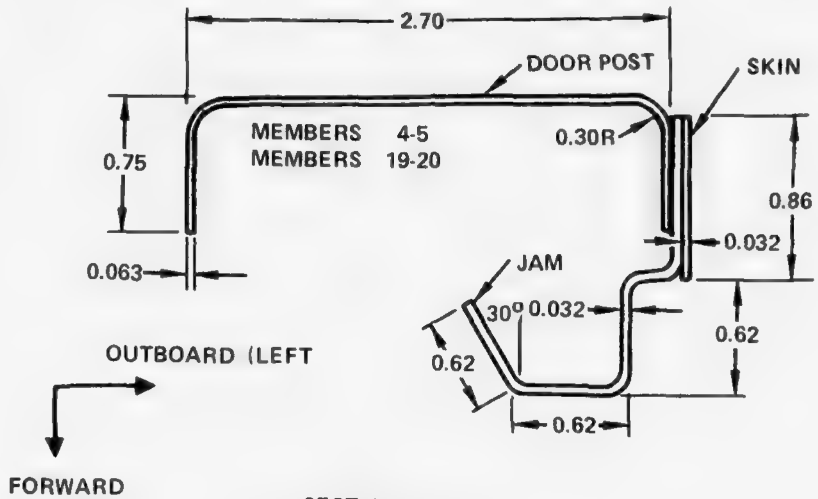
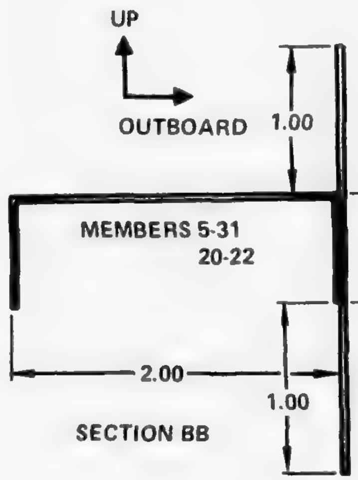


Figure B-8. Aft Fuselage Structure

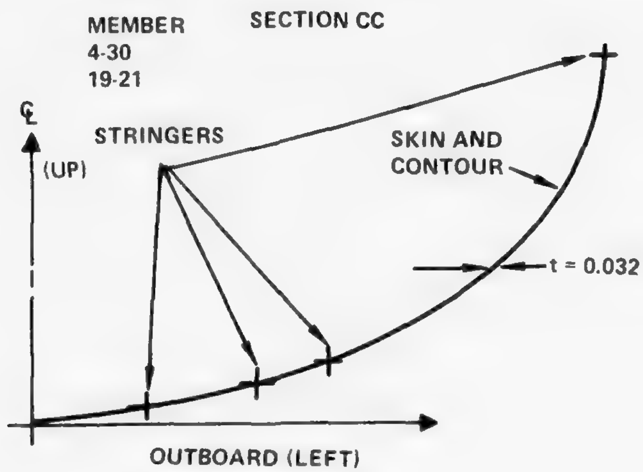


SECTION AA
(A) REAR DOOR POST



SECTION BB

(B) UPPER AFT FUSELAGE



(C) LOWER AFT FUSELAGE

Figure B-9 Aft Fuselge Structure Cross Sections

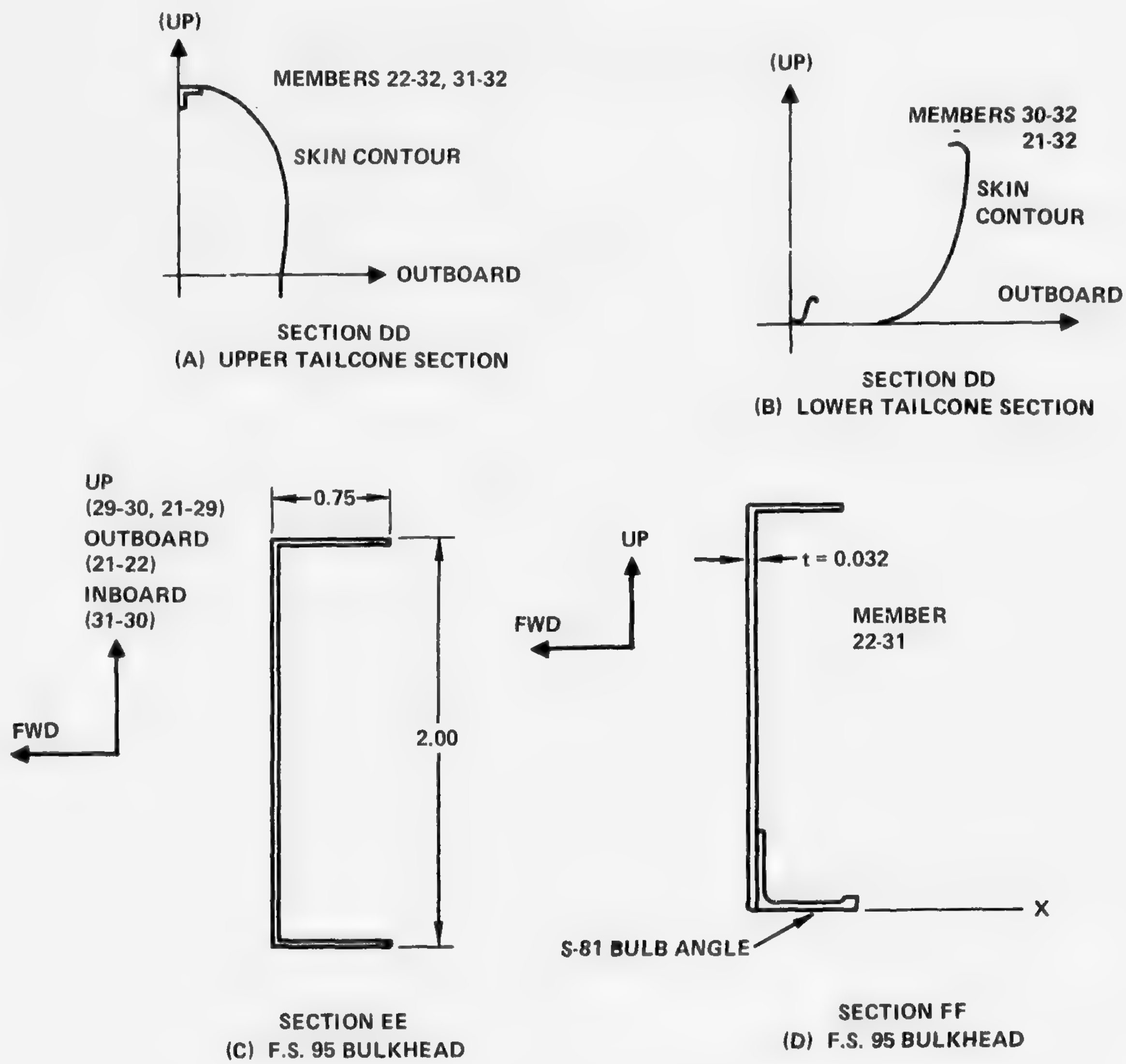


Figure B-10. Tail Cone and F.S. 95 Bulkhead Structure Cross Sections

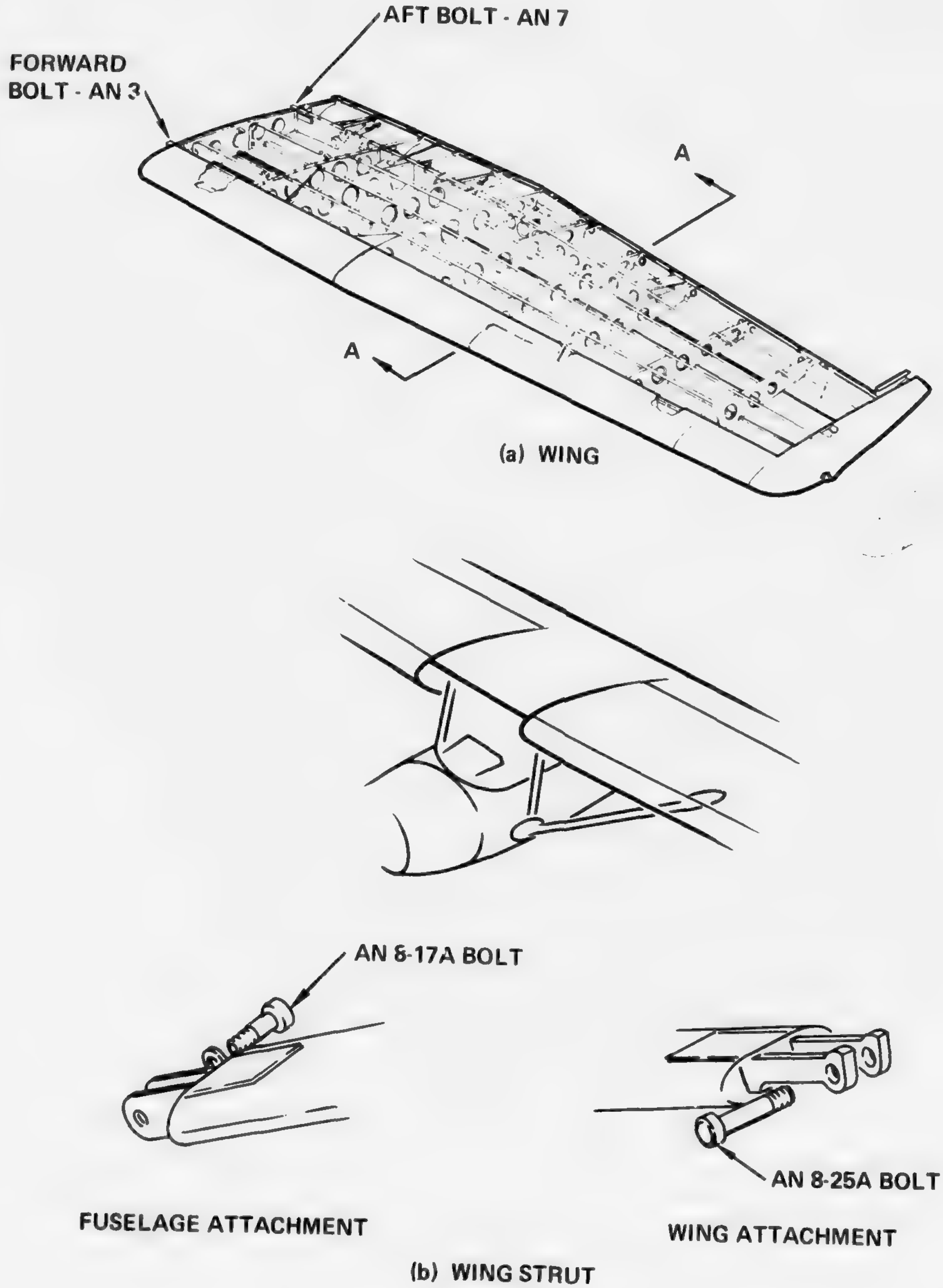
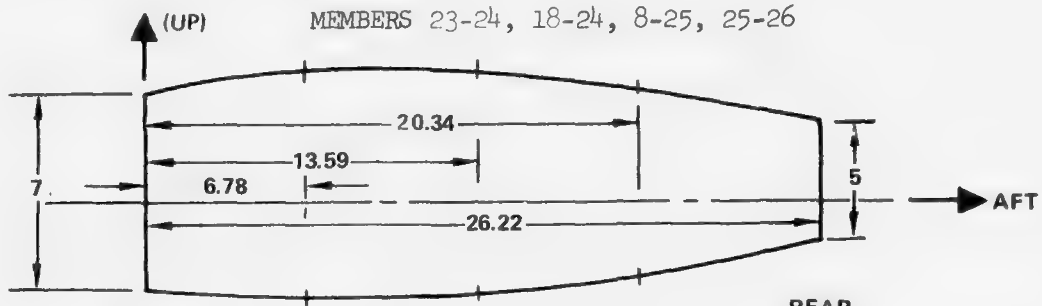
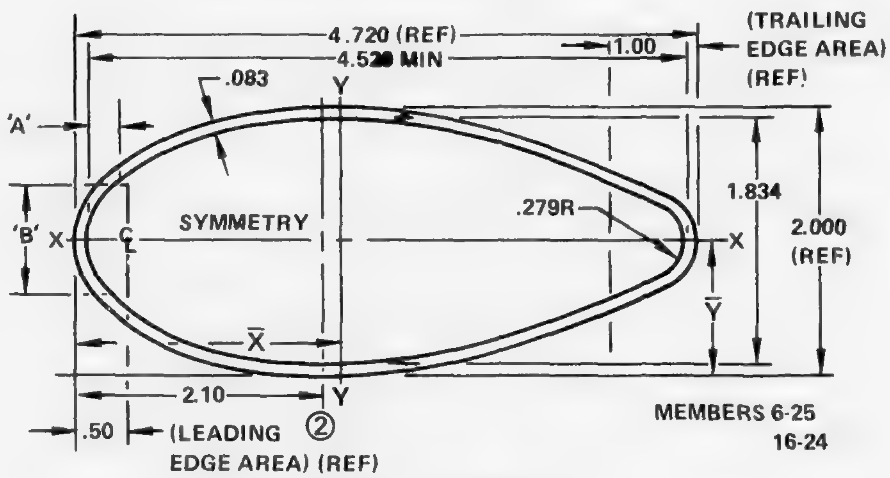


Figure B-11. Wing and Wing Strut Structure

MEMBERS 23-24, 18-24, 8-25, 25-26



SECTION A-A (FIGURE B-11)
(A) WING CROSS SECTION



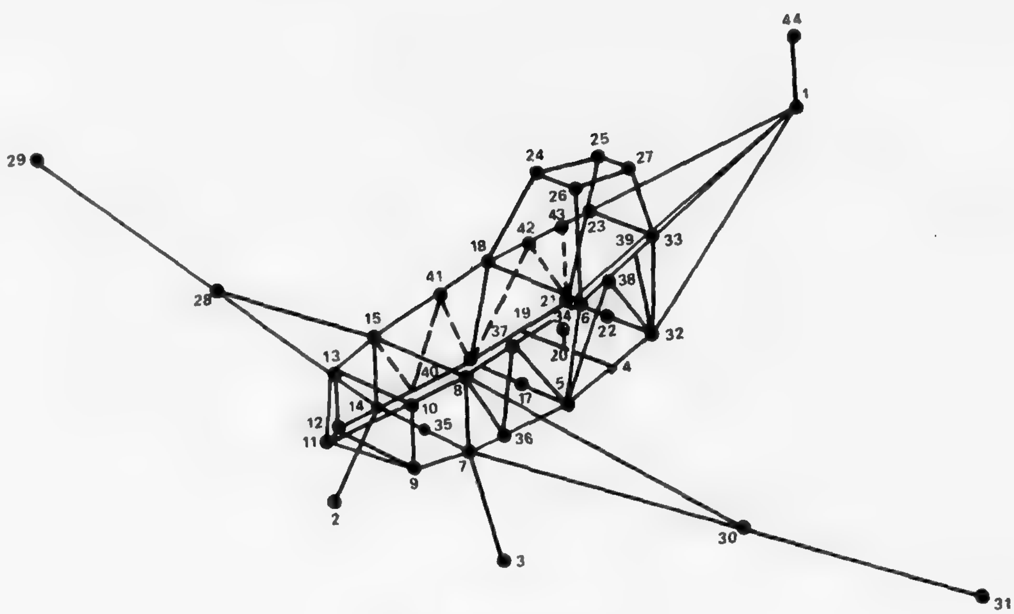
'A'	'B' MIN
.255	.955
.825	1.565
3.040	1.470
3.755	1.070

AREA SQ. IN.	$\bar{X}$	$\bar{Y}$	I_{XX}	I_{YY}	WEIGHT LBS. PER 100 IN.
.897	2.27	1.0	.4645	1.8686	8.97

(B) WING STRUT CROSS SECTION

Figure B-12. Wing and Wing Strut Structure Cross Sections

(a) OVERALL VIEW



(b) MATH MODEL

Figure B-13. Airplane B

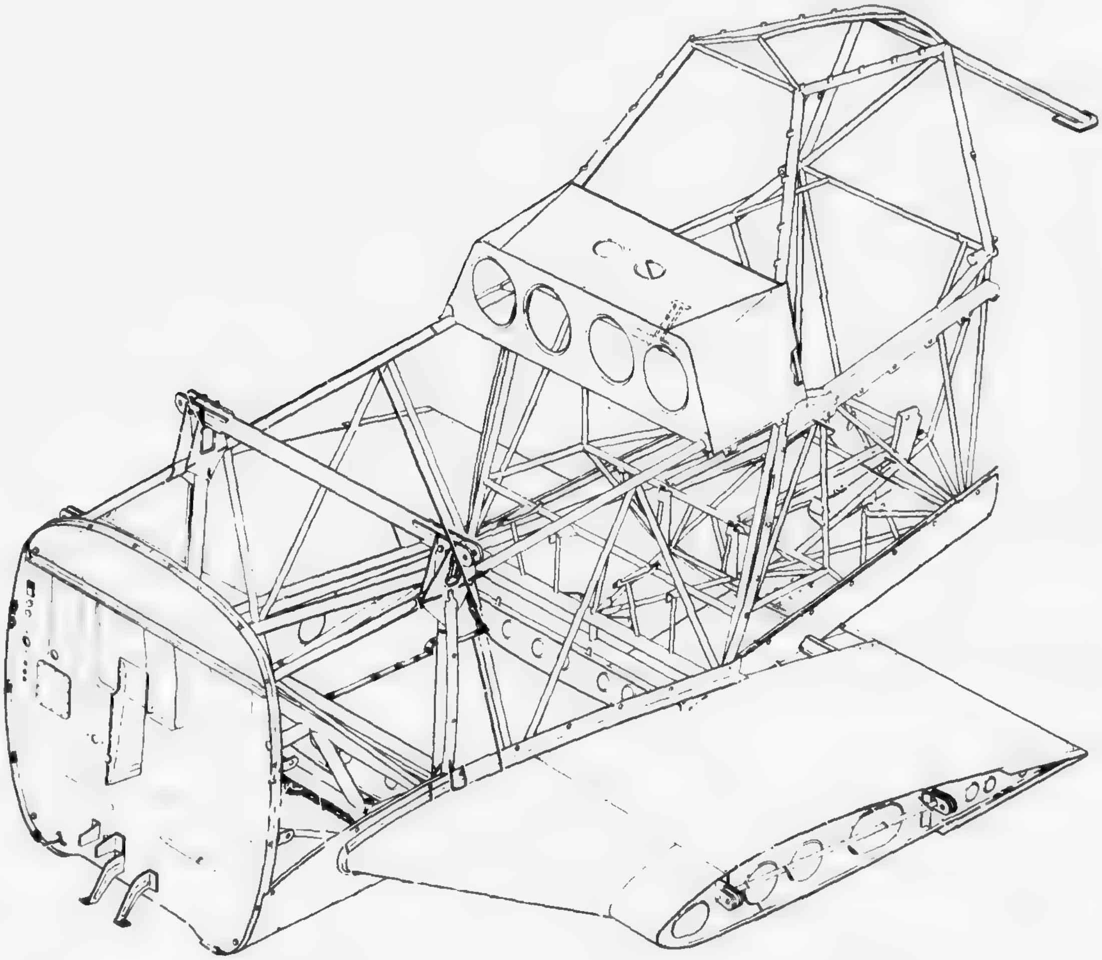
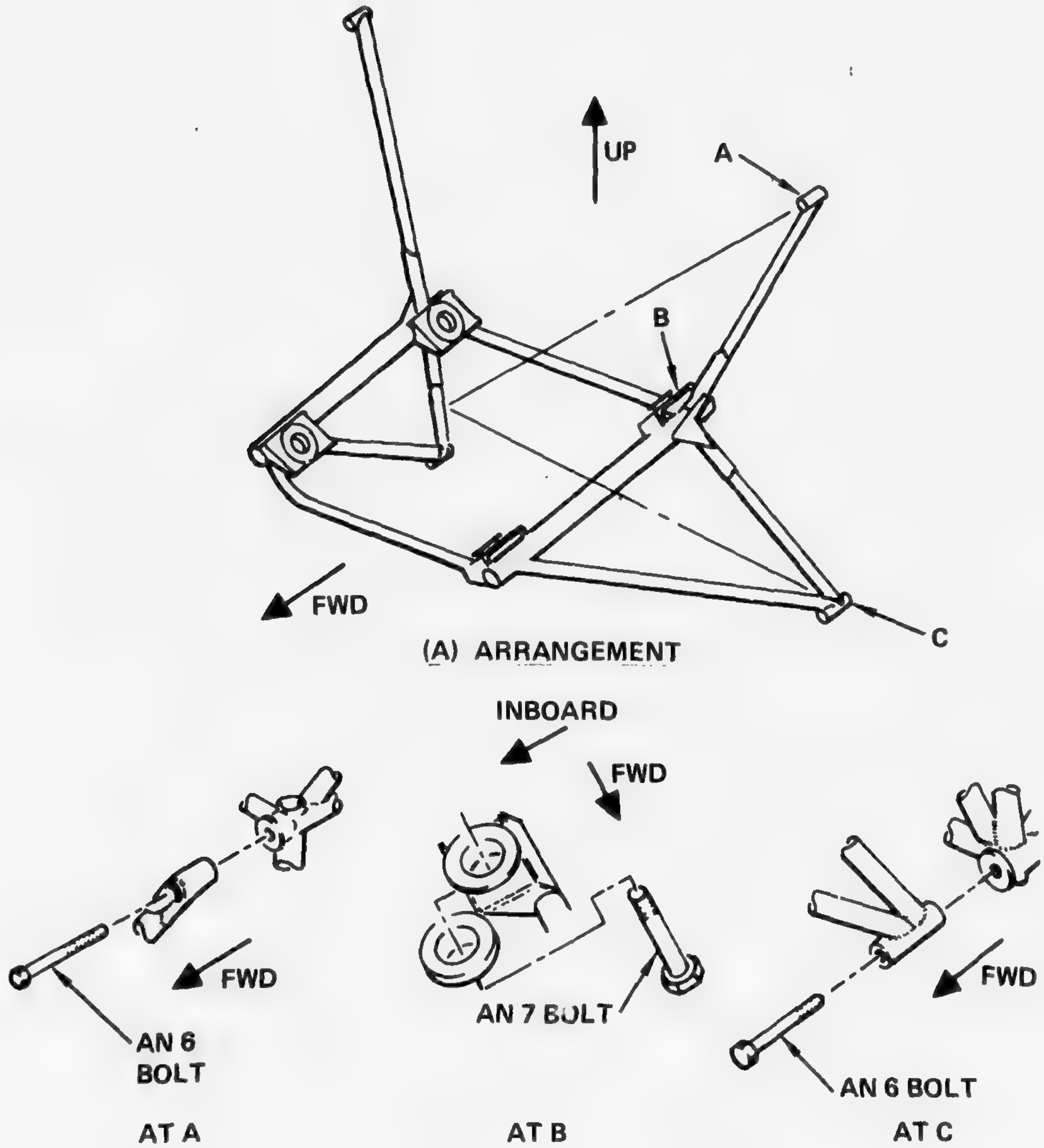


Figure B-14. Fuselage Structure



(B) ATTACHMENTS

MEMBERS 9-11, 10-11, 11-12, 11-13

Figure B-15. Engine Mount Arrangement

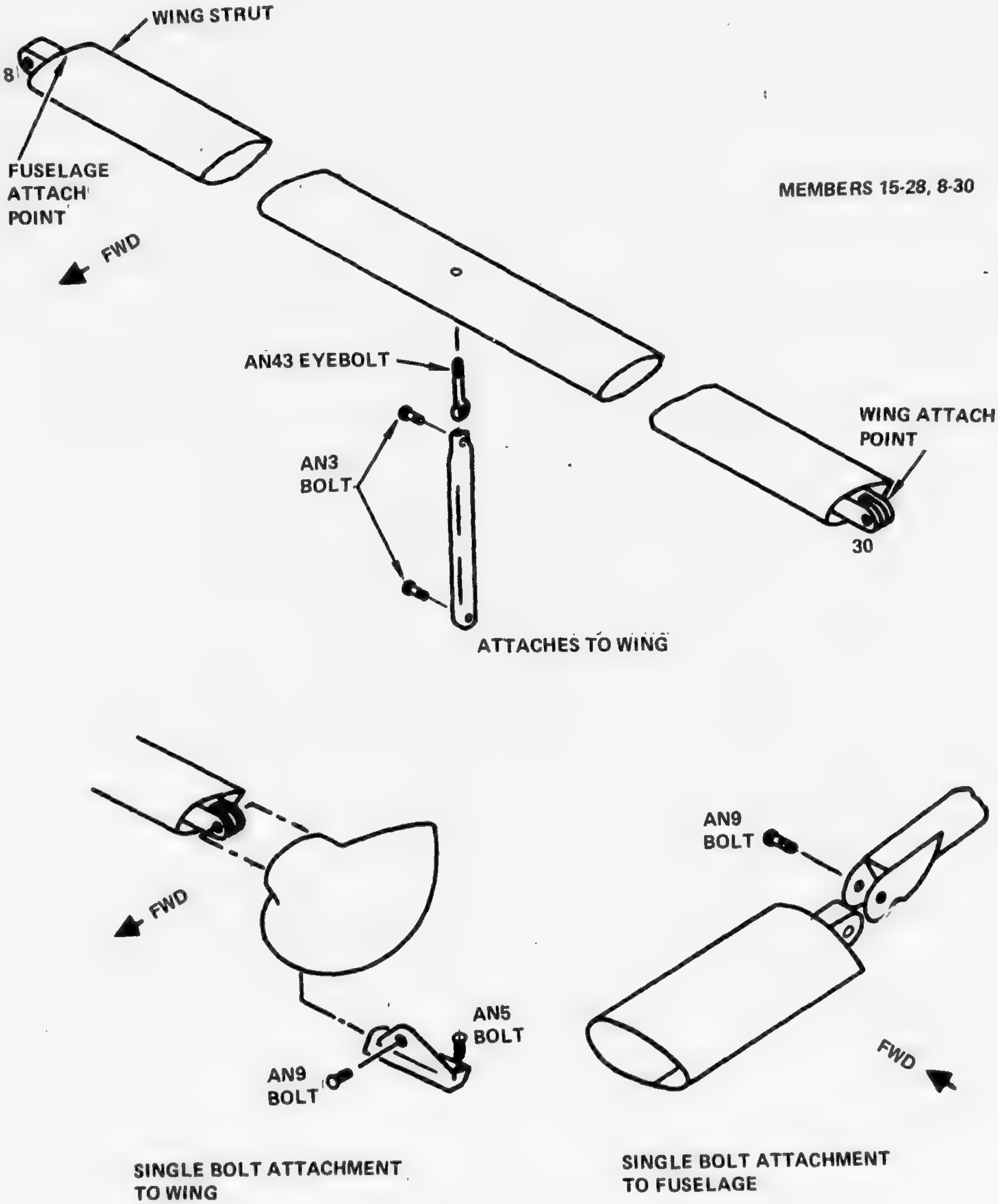


Figure B-16. Wing Strut Structure and Attachments

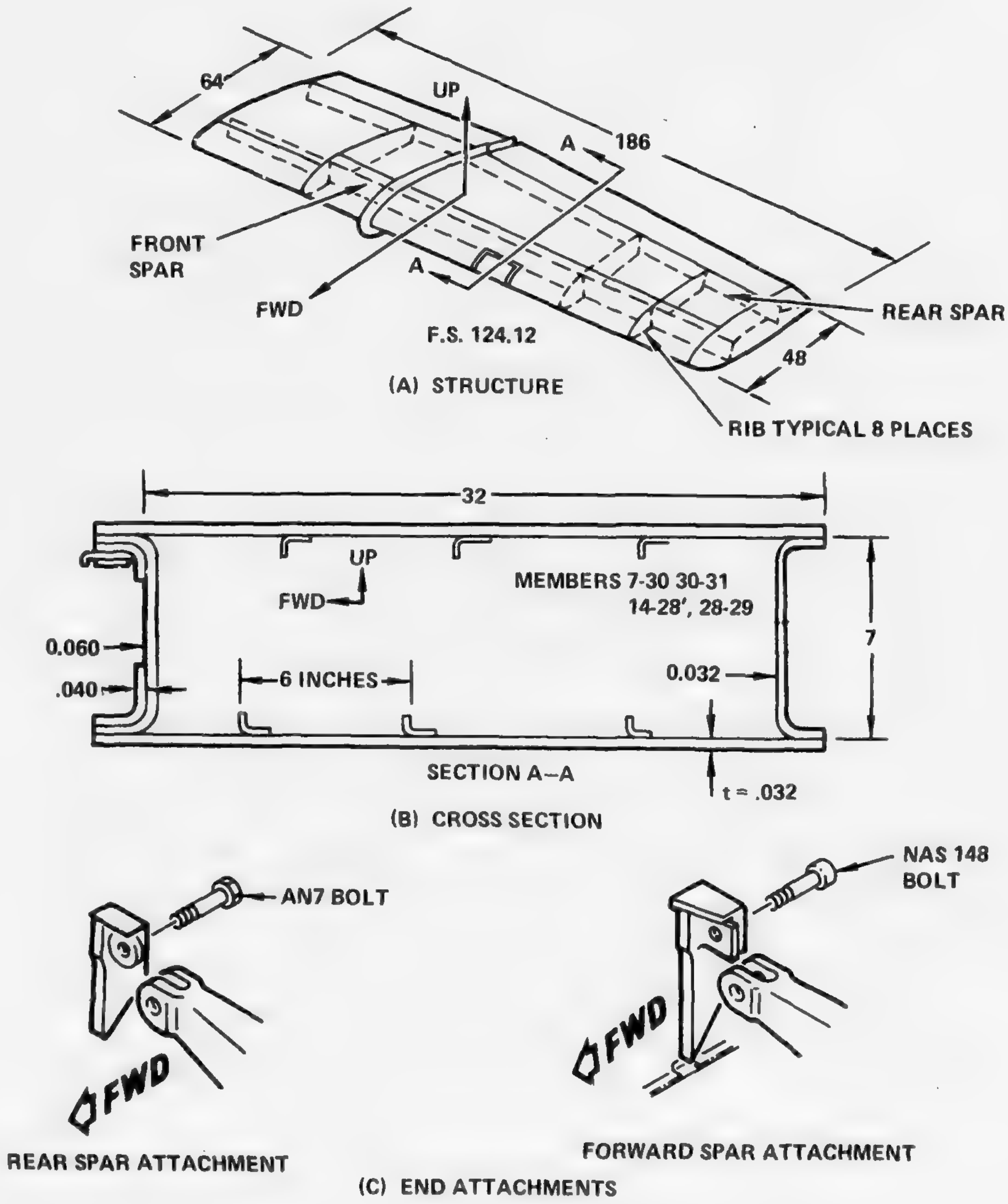


Figure B-17. Wing Structure, Cross Section and Attachments

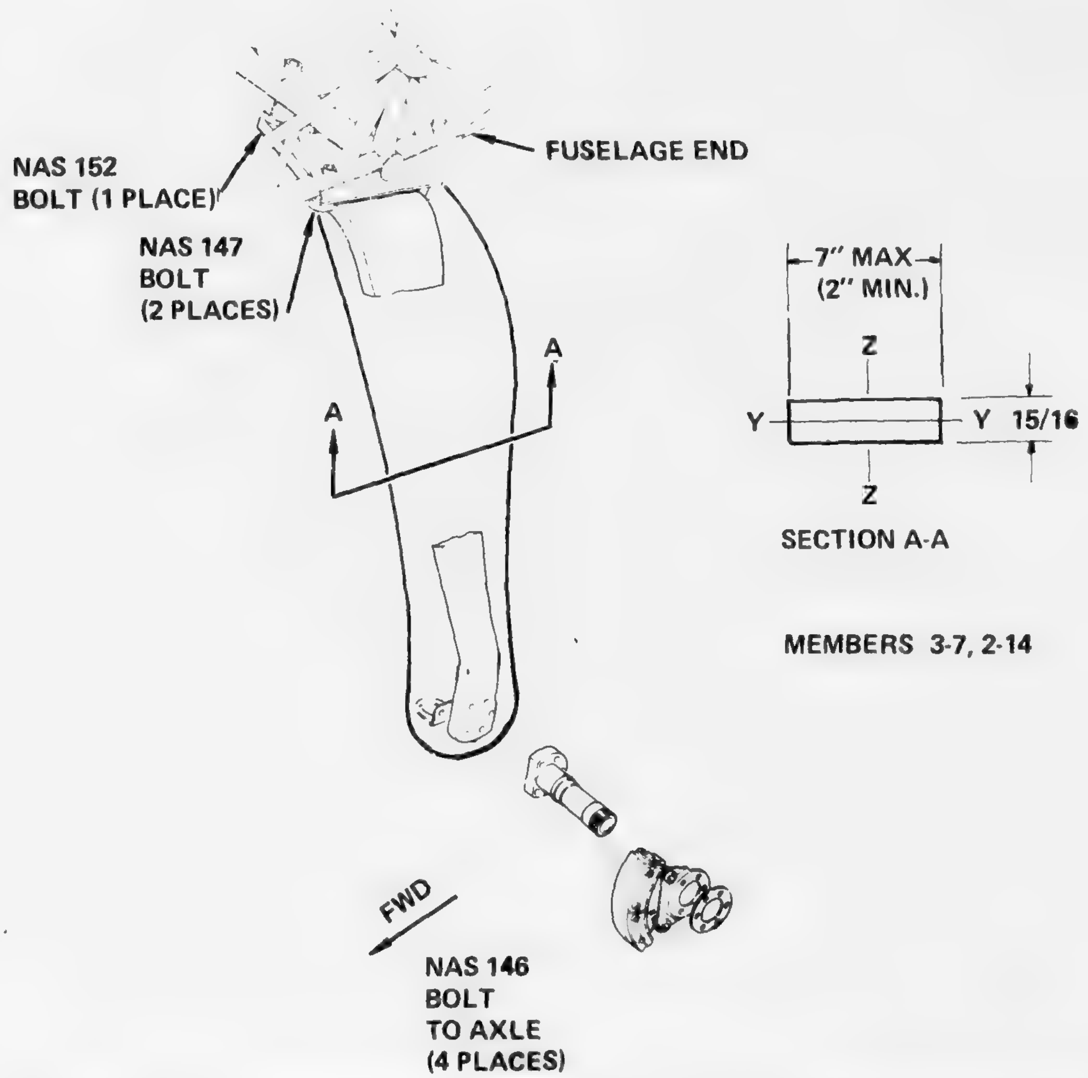


Figure B-18. Main Landing Gear Structure Cantilever Spring Cross Section

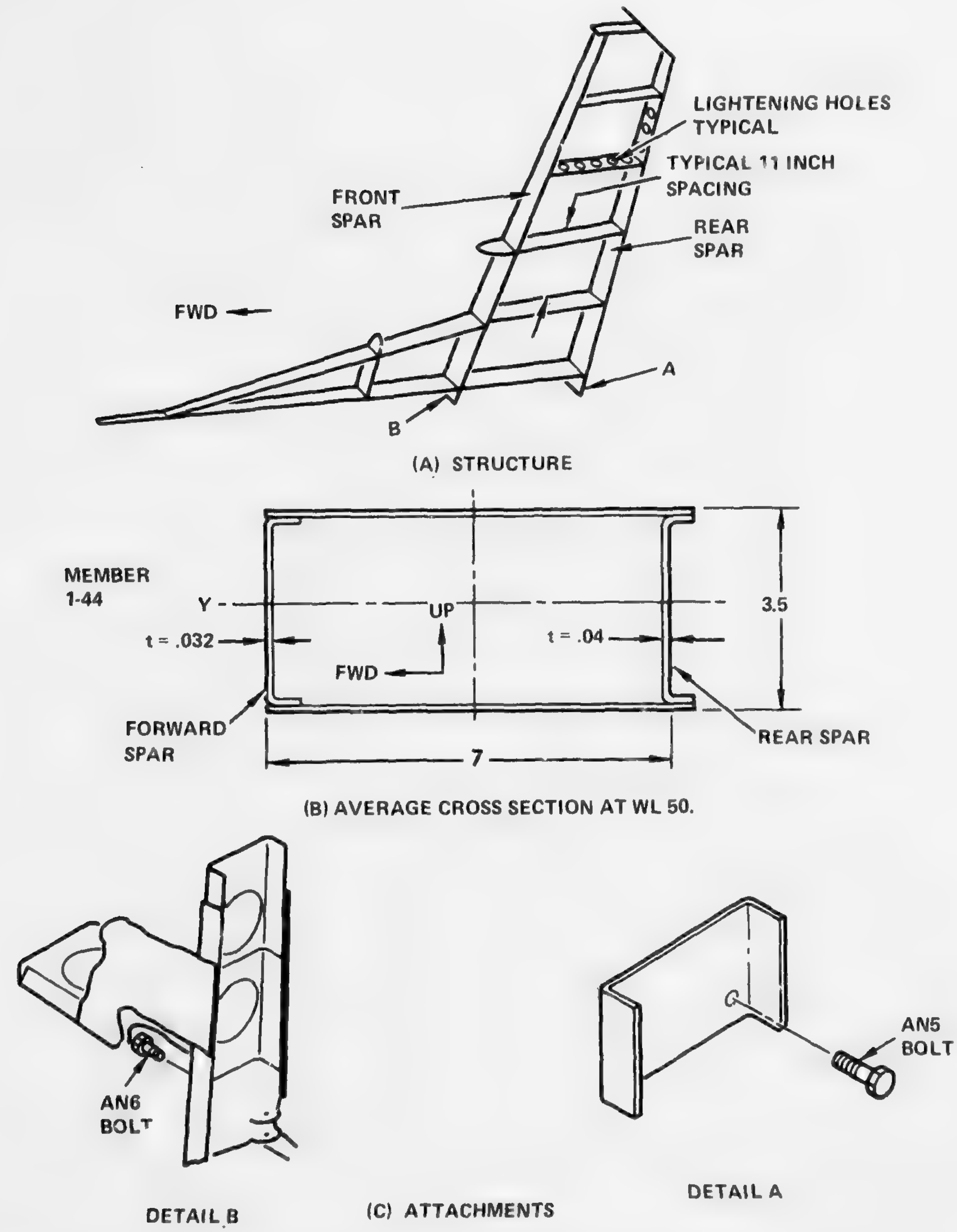


Figure B-19. Vertical Tail Structure, Cross Section and Attachments

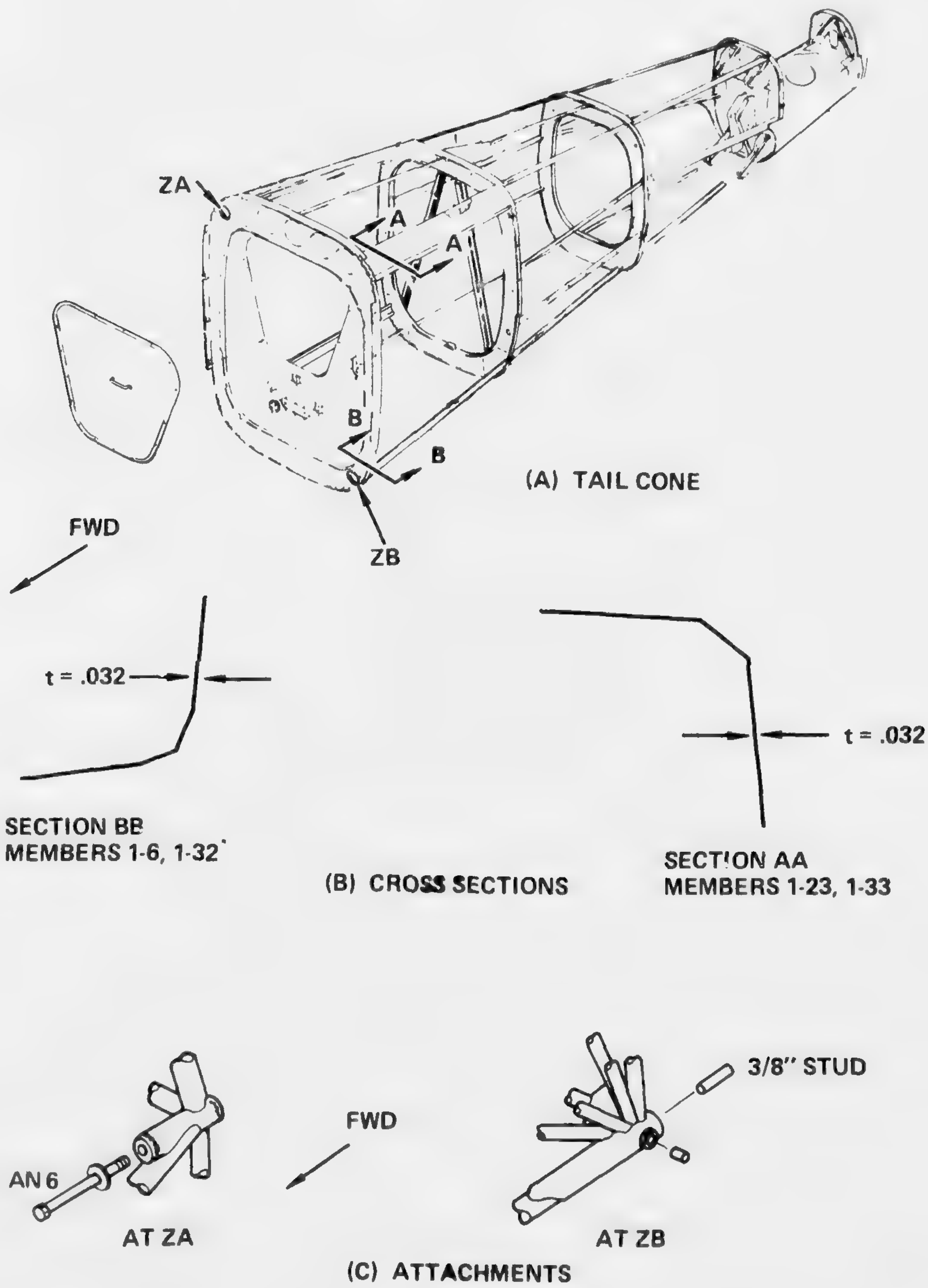


Figure B-20. Fuselage Tail Cone, Cross Section and Attachments

APPENDIX C

AIRPLANE MATH MODEL AND FILM DATA

C.1 INTRODUCTION

This appendix contains three sets of data for each of the two airplanes that were modeled as part of the assessment of program KRASH, modified as described in Section 4.0. Included in this appendix are airplane test data, film analysis data and model mass property, member property and model parameter data.

C.2 AIRPLANE A

C.2.1 Test Data

During the normal course of certifying general aviation airplanes for commercial use a series of tests are performed to show that the airplane is adequately designed to meet FAR 23 requirements. The results of these tests, where available and applicable are presented in Tables C-1 and C-2.

C.2.2 Film Analysis Data

The motion of Airplane A during the crash test was analyzed from 47 frame/second movie film. The test results indicated that the fuselage structure between F.S. 56 and 95 remained intact during the test. Consequently two locations, one located at F.S. 95 and WL 11.50 and the other located at F.S. 56.7 and W.L. 19.10, were used as reference points from which longitudinal and vertical displacements were obtained as a function of time. The change in displacement in a given time frame yields the velocity during that time period. A scale factor is used to translate film measurement into real displacement values. From the displacement data the longitudinal and vertical velocities in feet/second, for the two specified fuselage locations, are calculated. Positive values for displacement and velocity in

the longitudinal direction depict forward motion. Positive values for displacement and velocity in the vertical direction indicate upward motion. Figure C-1 shows a profile view of airplane A and the approximate location of the two fuselage reference points. The film analysis results for the aft door post (Reference point 1 in Figure C-1) are shown in Table C-3. Impact of the airplane with the dirt slope occurs at frame 8 or 9. Each frame represents 21.2 milliseconds of time. The data in Table C-3 indicate a change in forward (longitudinal) velocity of 6.2 ft/sec after nose gear impact. This reduction in speed is due, not to the nose gear impact resulting in the absorption of any significant energy, but to the fact that after the tow cable is released the airplane slows down just before impacting the slope. This is confirmed by the data which shows that the vertical velocity is still zero at spinner impact (frame 8). Table C-4 shows the film analysis results for the aft window (Reference point 2 in Figure C-1). The initial spinner impact velocity is within 2 percent of the value obtained from the aft doorpost film analysis. A 45 ft/sec initial spinner impact velocity was used in the analysis.

Table C-5 shows the results of the film analysis showing the rotation of the tailcone. The data is presented for 600 milliseconds after impact and is substantially more time than is required to evaluate the significant aspects of a crash of this nature. The rotation of the tailcone indicates that a failure occurs after approximately 60 milliseconds.

Table C-6 shows the results of the film analysis depicting fuselage rotation and rotational velocity. The two reference points are joined by a straight line which makes an angle of 11.22 degrees with respect to the airplane water line. The incremental change in this rotational angle is computed for each frame of film analysis. Thus at any instant in time the angle between the aircraft waterline and the ground is determined from the total angle less the reference 11.22 degrees. The rotational velocity is simply the change in rotation divided by the increment in time.

The cabin volume change sequence could not be accurately determined from the film analysis. The deformation of the forward doorpost with

respect to the assumed non-deformed aft doorpost was measured and was considered to represent longitudinal deformation. The upper and lower doorpost deformation was difficult to ascertain due to the absence of a fixed or non-deformable reference point. Consequently, deformation measurements were recorded at two approximate locations; W.L. 2.40 and W.L. 19.1, respectively (See Figure C-1). These locations correspond to the lower aft corner of the doorpost, the door latch and the upper aft corner of the doorpost, respectively. This data is presented in Table C-7.

C.2.2 Math Model Data

Airplane A math model data is presented in Figures C-2 through C-6 for the 35 mass, 69 member model and Figures C-7 through C-11 for the 21 mass, 32 member model. The sequence of presentation for each model is as follows:

- Mass coordinates and properties
- Member properties
- Member damping values
- Member frequencies
- Initial conditions, overall mass and C.G. properties

C.3 AIRPLANE B

C.3.1 Test Data

Applicable test data is presented in Tables C-8 and C-9.

C.3.2 Film Analysis Data

The notion of the Airplane B turnover test was analyzed from 24 frames/second movie film. Two locations on the fuselage, in what is considered non-deformable structure, were selected for performing the film analysis; these locations at F.S. 0.0, W.L. -13.8 and F.S. 110., W.L. 45. are shown in the profile view of Airplane B in Figure C-12. For each frame (every 41.7 milliseconds) longitudinal and vertical displacements were measured with respect to a fixed reference point. A scale factor was established for the purpose of translating film measurements into real displacement values. From the

displacement data the longitudinal and vertical velocities for the two locations on the fuselage were calculated. Positive values for displacement and velocity in the longitudinal direction depict forward motion. Positive values in the vertical direction indicate upward motion. Table C-10 presents the results of the film analysis. The pitch angle at any time of interest can be obtained by taking the rotation value shown in Table C-10 and subtracting 28.19 degrees. Initial impact is shown at time = 0.0. The angle at impact is approximately 38.6 degrees. The c.g. velocity is obtained from rigid body relationships as follows:

$$\dot{X}_{C.G.} = \dot{X}_i - (\cos\theta\, r_{zi} - \sin\theta\, r_{xi})\dot{\theta}$$

$$\dot{Z}_{C.G.} = \dot{Z}_i + (\sin\theta\, r_{zi} + \cos\theta\, r_{xi})\dot{\theta}$$

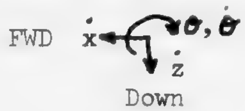
where

$\dot{X}_{C.G.}$, $\dot{Z}_{C.G.}$ = longitudinal and vertical velocity at C.G., respectively

r_x, r_z = longitudinal and vertical distance from c.g. to location of interest, respectively (+ forward, + down, from c.g.)

θ, $\dot{\theta}$ = pitch angle (radians) and rate (radians/sec), respectively.

Positive coordinates for $\dot{X}$, $\dot{Z}$, θ, $\dot{\theta}$ are shown below.



The position of the camera used for the film analysis, relative to the airplane is such that after the airplane rotates over onto its turnover structure the angle of impact is difficult to judge. For the airplane to be in a position for both the vertical tail and the forward turnover structure to contact the ground simultaneously the angle theta (θ), shown in Table C-10, should be greater than 190 degrees, (when the reference angle is included). The data presented in Table C-10 is intended to include the turnover contact at approximately 1500 milliseconds after impact. However, the angle assiciated with this impact (178.55) is distorted due to the positioning of the 24 frame/second camera relative to the airplane. Consequently, still photographs of the airplane at different positions during the latter stages of the overturn (obtained from 1000 frame/second film) and a geometry layout of the

airplane were used to complement the 24 frame/second analysis. Thus, the second impact was determined to occur at approximately 1.5 seconds after impact with an impact angle of 162 degrees and an initial rotational pitch rate of 89.4 degrees/second. The pitch rate corresponds to the average value between 1460 and 1540 milliseconds after impact.

C.3.3 Math Model Data

Airplane B math model data is presented in Figures C-13 through C-17 for the 44 mass, 81 member model and Figures C-18 through C-22 for the 25 mass, 38 member model. These models were used in analyzing the initial impact condition. The sequence of presentation for each model is as follows:

- o Mass coordinates and properties
- o Member properties
- o Member damping values
- o Member frequencies
- o Initial conditions, overall mass and c.g. properties.

Twenty-four mass (37 member) and 43 mass (80 member) math models were used to analyze the second (turnover structure) impact. The 24 mass model is the same as the 25 mass model except for the representation of mass 25 for the vertical tail. Similarly, the 44 mass model differs from the 43 mass model due to the representation of the vertical tail. Consequently, the data for the 24 and 43 mass models are not presented. The initial conditions, mass and c.g. properties for both the 24 mass and 43 mass models are presented in Figures C-23 and C-24, respectively.

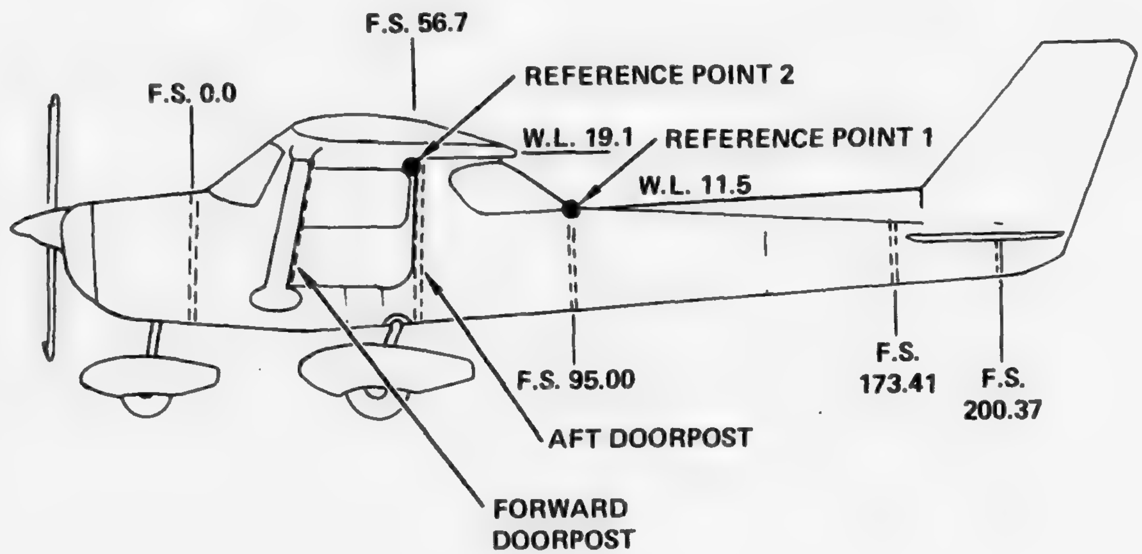


Figure C-1. Profile View of Airplane A

TABLE C-1. AIRPLANE A STRUCTURE TEST LOAD-DEFLECTION DATA

Structure	Design Load (lb.)	Deflection at Design Load (in.)	Rotation at Design Load (deg.)
Engine Mount[e]			
Longitudinal	-	-	-
Side	820	.81	.77 (Yaw)[d]
Vertical	2456	.41	.76 (Pitch)
Main Landing Gear[f]			
Longitudinal	1277	.45	-
Side	1200	-	-
Vertical	3519	5.43	-
Nose Landing Gear[g]			
Longitudinal	908	.69	
Side	794	.32	-
Vertical	1134	-	-
Wing			
Bending (j)	463281[a]	7.56[b]	2.25 (Roll)
Torsion	47826[a]	4.2[b]	5.47
Shear (j)	6155	7.56	2.25 (Roll)
Tailcone[h]			
Vertical	591	1.71	.50 (Pitch)[c]
Side	542	2.55	.68 (Yaw)

(a) Units: in-lb.

(b) Measured at wing station 180 front spar, relative to wing station 100.

(c) Referenced to F.S. 57.

(d) Referenced to F.S. 0.0

(e) Load point (F.S. 18.5, WL-3.6, B.L. 0.0), deflections and rotations measured relative to firewall (F.S. 0.0)

(f) Load point (F.S. 47.25, WL 34.75, B.L. 38.5), deflections and rotations measured relative to firewall.

(g) Load point (F.S. 10.75, W.L. 45.17, B.L. 0.0), deflections and rotations measured relative to firewall

(h) Load point (F.S. 200), deflections and rotations measured relative to F.S. 57.

(i) Airplane axes apply for all structures except wing.

(j) Load applied at wing station 20.5.

TABLE C-2. AIRPLANE A FUSELAGE TEST VERTICAL LOAD-DEFLECTION DATA

Fuselage Station (F.S.)	Design Load (lb)	Deflection at Design Load (in)	Rotation at Design Load (deg)
0	1083	.09	0
18.5	3396	.125	-
56.	3914	.202	-
71	-	.234	-
95	152	.375	.11 (pitch)[a]

(a) Referenced to Firewall F.S. 0.0

TABLE C-3. AIRPLANE A FILM ANALYSIS DATA (Aft Door Post)				
Frame	Vertical Displacement (g)	Vertical Velocity (a)	(g) Longitudinal Displacement	Longitudinal Velocity (a)
5	0.00	0.000	0.635	49.107
6	0.00	0.000	0.635	49.107
7(b)	--	--	0.67	51.814
8(c)	0.00	0.000	0.59	45.627
9(d)	0.02	1.547	0.55	42.534
10	0.07	5.413	0.50	38.667
11	0.11	8.507	0.42	32.481
12	0.09	6.960	0.39	30.161
13	0.08	6.187	0.36	27.841
14	0.09	6.960	0.25	19.334
15	0.15	11.600	0.17	13.147
16	0.12	9.280	0.18	13.920
17	0.06	4.640	0.10	7.734
18	0.10	7.734	0.08	6.187
19	0.07	5.413	0.03	2.320
20	0.10	7.734	0.04	3.093
21	0.07	5.413	0.00	0.000
22	0.06	4.640	0.01	0.773
23	0.08	6.187	0.05	3.867
24	0.05	3.867	0.07	5.413
25	0.08	6.187	0.00	0.000
26	0.05	3.867	-0.03	-2.320
27	0.06	4.640	0.01	0.773
28	0.03	2.320	0.05	3.867
29	0.02	1.547	0.04	3.093
30	-0.01	-0.773	0.01	0.773

(a) $V\ (\text{ft/sec}) = \frac{(19.745)(47)\ (\text{Displacement})}{12}$

(b) Nose Gear Impact

(c) Spinner Impact

(d) Forward Lower Cowl Impact

(e) Positive Directions are up and forward

(f) Only Frame 5 through 30 Shown

(g) Incremental values

TABLE C-4. AIRPLANE A FILM ANALYSIS DATA (Aft Window)

Frame	Vertical Displacement (g)	Vertical Velocity (a)	(g) Longitudinal Displacement	Longitudinal Velocity (a)
5	--	--	0.605	46.787
6	0.00	0	0.605	46.787
7(b)	0.00	0	0.60	46.400
8(c)	0.00	0	0.60	46.400
9(d)	0.00	0	0.53	40.987
10	0.05	3.867	0.49	37.894
11	0.02	1.547	0.44	34.027
12	0.29	22.427	0.35	27.067
13	0.43	33.254	0.29	22.427
14	0.32	24.747	0.23	17.787
15	0.31	23.974	0.18	13.920
16	0.30	23.200	0.17	13.147
17	0.26	20.107	0.15	11.600
18	0.16	12.374	0.14	10.827
19	0.20	15.467	0.10	7.734
20	0.17	13.147	0.07	5.413
21	0.17	13.147	0.05	3.867
22	0.08	6.187	0.10	7.734
23	0.08	6.187	0.11	8.507
24	0.13	10.054	0.16	12.374
25	0.08	6.187	0.09	6.960
26	0.06	4.640	0.08	.187
27	0.04	3.093	0.03	2.320
28	0.04	3.093	0.02	1.547
29	0.01	0.773	0.06	4.640
30	0.06	4.640	0.01	0.773

(a) $V(\text{ft/sec}) = \dfrac{(19.745)\ (47)\ (\text{Displacement})}{12}$

(b) Nose Gear Impact

(c) Spinner Impact

(d) Forward Lower Cowl Impact

(e) Positive Directions are Up and Forward

(f) Only Frames 5 through 30 Shown

(g) Incremental values

TABLE C-5. AIRPLANE A TAIL CONE FILM ANALYSIS

Time After Spinner Impact(Milliseconds)	Tail Cone Rotation (Degrees) (a)
30	0.0
60	-3.5
90	-13.0
120	-20.5
150	-33.0
180	-42.5
210	-50.5
240	-57.0
270	-62.0
300	-68.5
330	-74.0
360	-80.0
390	-79.0
420	-76.5
450	-76.0
480	-73.0
510	-72.0
540	-72.0
570	-72.0
600	-65.5

(a) Tailcone rotation is with respect to the fuselage. Positive indicates nose down rotation. Negative sign indicates the tail cone angle is below the instantaneous fuselage reference line (water line).

(b) Only Frames 5 through 30 Shown

TABLE C-6. AIRPLANE A FILM ANALYSIS OF FUSELAGE ROTATION AND ROTATIONAL VELOCITY

Frame	Rotation, θ (a) (Degrees) (b)	Rotational Velocity, $\dot{\theta}$, (Degrees/Second)(b)
5	11.22	0
6	11.22	0
7	11.22	0
8(c)	10.64	0
9	10.64	-4.98
10	10.53	22.64
11	11.01	89.94
12	12.92	98.56
13	15.02	-213.43
14	10.48	-494.67
15	-.04	-321.11
16	-6.87	-218.14
17	-11.51	-258.11
18	-17.00	-298.03
19	-23.34	-157.87
20	-26.70	-168.01
21	-30.27	-112.42
22	-32.66	-175.10
23	-36.39	-68.49
24	-37.85	-76.45
25	-39.48	-165.86
26	-43.01	-109.18
27	-45.33	-31.60
28	-46.00	+52.21
29	-44.89	-31.34
30	-45.56	10.03

(a) Fuselage rotation angle = θ - 11.22°

(b) Positive indicates nose down rotation

(c) Spinner Impact

(d) Only Frames 5 through 30 Shown

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TABLE C-7. AIRPLANE A FILM ANALYSIS FOR CABIN DEFORMATION CHANGE (a)

Time After Impact (Seconds)	Deflection (inches)			
	Incremental at WL 19.10	Cumulative at WL 19.10	Incremental at WL 2.40	Cumulative at WL 2.40
0.0000	0.00	0.00	0.00	0.00
0.0156	0.21	0.20	2.29	2.29
0.0312	0.76	0.97	3.12	5.42
0.0468	0.38	1.35	1.15	6.56
0.0624	0.22	1.57	0.42	6.98
0.0780	0.16	1.73	0.63	7.61
0.0936	0.22	1.95	0.63	8.24
0.1092	0.22	2.17	0.52	8.76
0.1248	0.27	2.44 (c)	0.73	9.49
0.1404	-0.06	2.38	0.73	10.22 (c)
0.1560	-0.16	2.22	-0.42	9.84
0.1716	-0.16	2.06	-0.31	9.49
0.1872	-0.11	1.95	-0.21	9.28
0.2028	-0.11	1.84	-0.10	9.18
0.2184	-0.11	1.73	-0.21	8.97
0.2340	0.00	1.73	-0.10	8.87

(a) Deformation of the forward doorpost with respect to the aft doorpost (assumes negligible aft doorpost deformation)

(b) Final deflections are:

1.20 inches at WL 19.10
7.91 inches at WL 2.40
7.03 inches at WL -8.00

(c) Peak deflection

MASS DATA

	WEIGHTS	MASS COORDINATES F.S.,W.L.,B.L.			MASS MOMENTS OF INERTIA (LB-IN-SEC**2)			
I	W	X''	Y''	Z''	IX	IY	IZ	I
1	1.030000D 01	-1.075000D 01	0.0	-3.459000D 01	6.400000D-01	1.410000D 00	6.400000D-01	1
2	2.025000D 01	4.760000D 01	3.979000D 01	-3.459000D 01	8.120000D-01	1.797000D 00	8.120000D-01	2
3	2.025000D 01	4.760000D 01	-3.979000D 01	-3.459000D 01	8.120000D-01	1.797000D 00	8.120000D-01	3
4	2.610000D 01	5.313000D 01	1.400000D 01	-1.944000D 01	3.780000D 00	5.820000D 00	5.900000D 00	4
5	4.519500D 01	5.752000D 01	2.125000D 01	2.544000D 01	7.280000D 01	4.640000D 01	5.040000D 01	5
6	1.970000D 01	2.098000D 01	1.628000D 01	-1.766000D 01	4.900000D 00	1.130000D 01	1.190000D 01	6
7	1.970000D 01	2.404000D 01	1.628000D 01	6.440000D 00	4.900000D 00	1.130000D 01	1.190000D 01	7
8	5.165000D 01	2.652000D 01	2.125000D 01	2.615000D 01	8.370000D 01	5.968000D 01	6.545000D 01	8
9	2.274400D 01	0.0	1.450000D 01	-1.972000D 01	7.127000D 00	1.128000D 01	8.850000D 00	9
10	2.274400D 01	0.0	1.450000D 01	6.440000D 00	7.127000D 00	1.128000D 01	8.850000D 00	10
11	2.274400D 01	0.0	-1.450000D 01	-1.972000D 01	7.127000D 00	1.128000D 01	8.850000D 00	11
12	2.274400D 01	0.0	-1.450000D 01	6.440000D 00	7.127000D 00	1.128000D 01	8.850000D 00	12
13	2.774910D 02	-1.642000D 01	0.0	-1.850000D 00	5.800000D 01	7.473000D 01	7.648000D 01	13
14	2.120000D 01	-7.390000D 00	0.0	-2.296000D 01	2.480000D 00	2.740000D 00	4.620000D-01	14
15	3.320000D 01	2.098000D 01	0.0	-1.766000D 01	7.318000D 00	1.699000D 01	1.787000D 01	15
16	1.970000D 01	2.098000D 01	-1.628000D 01	-1.766000D 01	4.900000D 00	1.130000D 01	1.190000D 01	16
17	1.970000D 01	2.404000D 01	-1.628000D 01	6.440000D 00	4.900000D 00	1.130000D 01	1.190000D 01	17
18	5.165000D 01	2.652000D 01	-2.125000D 01	2.615000D 01	8.370000D 01	5.968000D 01	6.545000D 01	18
19	2.610000D 01	5.313000D 01	-1.400000D 01	-1.944000D 01	3.780000D 00	5.820000D 00	5.900000D 00	19
20	4.519500D 01	5.752000D 01	-2.125000D 01	2.544000D 01	7.280000D 01	4.640000D 01	5.040000D 01	20
21	9.637000D 00	9.500000D 01	-1.200000D 01	-1.165000D 01	1.510000D 00	1.975000D 01	1.953000D 01	21
22	9.637000D 00	9.500000D 01	-1.225000D 01	9.500000D 00	1.510000D 00	1.975000D 01	1.953000D 01	22
23	3.897000D 00	2.652000D 01	-1.919700D 02	2.712000D 01	4.500000D-01	1.780000D 00	2.147000D 00	23
24	7.181500D 01	2.652000D 01	-8.224000D 01	2.712000D 01	4.680000D 02	3.540000D 01	5.020000D 02	24
25	7.181500D 01	2.652000D 01	8.224000D 01	2.712000D 01	4.680000D 02	3.540000D 01	5.020000D 02	25
26	3.897000D 00	2.652000D 01	1.919700D 02	2.712000D 01	4.500000D-01	1.780000D 00	2.147000D 00	26
27	6.690000D 01	5.313000D 01	0.0	-1.944000D 01	2.900000D 00	4.500000D 00	4.500000D 00	27
28	1.872000D 02	5.313000D 01	0.0	-7.446000D 00	9.300000D 00	6.700000D 00	1.120000D 01	28
29	4.000000D 01	9.500000D 01	0.0	-1.165000D 01	1.493000D 01	7.310000D 00	1.493000D 01	29
30	9.637000D 00	9.500000D 01	1.200000D 01	-1.165000D 01	1.510000D 00	1.975000D 01	1.953000D 01	30
31	9.637000D 00	9.500000D 01	1.225000D 01	9.500000D 00	1.510000D 00	1.975000D 01	1.953000D 01	31
32	6.340000D 01	2.003800D 02	0.0	5.700000D 00	2.670000D 01	3.436000D 01	4.266000D 01	32
33	6.000000D 01	2.872000D 01	-8.224000D 01	2.712000D 01	3.910000D 02	3.020000D 01	4.195000D 02	33
34	6.000000D 01	2.672000D 01	8.224000D 01	2.712000D 01	3.910000D 02	3.020000D 01	4.195000D 02	34
35	1.360000D 02	5.313000D 01	0.0	9.560000D 00	4.000000D 00	3.700000D 00	3.300000D 00	35

Figure C-2 Airplane A 35 Mass, 69 Member Math Model Mass Data

BEAM			MODULUS OF ELASTICITY	AREA	MODULUS OF RIGIDITY	MOMENTS OF INERTIA			LENGTH	DAMPING RATIO	BEAM		
IJ	I	J	E	A	G	JX	I(YY)	I(ZZ)	XLB	CBAR	IJ	I	J
1	1	14	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	1.2106D 01	2.0000D-02	1	1	14
2	2	4	3.0000D 07	2.0700D 00	1.1000D 07	3.0497D 00	6.8400D-02	2.9613D 00	3.0418D 01	2.0000D-02	2	2	4
3	3	19	3.0000D 07	2.0700D 00	1.1000D 07	3.0497D 00	6.8400D-02	2.9813D 00	3.0418D 01	2.0000D-02	3	3	19
4	4	5	1.0500D 07	5.0460D-01	4.0000D 06	7.4380D-01	3.7000D-01	3.7380D-01	4.5673D 01	2.0000D-02	4	4	5
5	4	6	1.0500D 07	1.4750D-01	4.0000D 06	6.9980D 01	4.1760D 01	4.8220D 01	3.2280D 01	2.0000D-02	5	4	6
6	4	27	1.0500D 07	2.4410D 00	4.0000D 06	4.0348D 01	1.4070D 01	2.6278D 01	1.4000D 01	2.0000D-02	6	4	27
7	4	30	1.0500D 07	8.1640D-01	4.0000D 06	6.6660D 01	2.7430D 01	3.9230D 01	4.2635D 01	2.0000D-02	7	4	30
8	5	8	1.0500D 07	6.7270D-01	4.0000D 06	1.9791D 01	1.5000D 01	4.7910D 00	3.1008D 01	2.0000D-02	8	5	8
9	5	20	1.0500D 07	5.2270D-01	4.0000D 06	6.8710D-01	3.2070D-01	3.6640D-01	4.2500D 01	2.0000D-02	9	5	20
10	5	31	1.0500D 07	1.8100D-01	4.0000D 06	1.5730D-01	9.5100D-02	6.2200D-02	4.1711D 01	2.0000D-02	10	5	31
11	6	7	1.0500D 07	8.5850D-01	4.0000D 06	2.6255D 00	5.9860D-01	2.0269D 00	2.4293D 01	2.0000D-02	11	6	7
12	6	9	1.0500D 07	1.8760D-01	4.0000D 06	1.1160D-01	3.4400D-02	7.7400D-02	2.1156D 01	2.0000D-02	12	6	9
13	6	15	1.0500D 07	6.3880D-01	4.0000D 06	1.6114D 00	1.5741D 00	3.7300D-02	1.6280D 01	2.0000D-02	13	6	15
14	6	25	1.0400D 07	6.4700D-01	4.0000D 06	2.3331D 00	1.8686D 00	4.6450D-01	7.9917D 01	2.0000D-02	14	6	25
15	7	8	1.0500D 07	8.5850D-01	4.0000D 06	2.6255D 00	5.9860D-01	2.0269D 00	2.0478D 01	2.0000D-02	15	7	8
16	7	10	1.0500D 07	2.4530D-01	4.0000D 06	2.6630D-01	1.8000D-02	2.4830D-01	2.4106D 01	2.0000D-02	16	7	10
17	7	17	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	3.2560D 01	2.0000D-02	17	7	17
18	8	18	1.0500D 07	5.2270D-01	4.0000D 06	6.8710D-01	3.2070D-01	3.6640D-01	4.2500D 01	2.0000D-02	18	8	18
19	8	25	1.0500D 07	1.5830D 00	4.0000D 06	2.3288D 02	1.6380D 01	2.1650D 02	6.0998D 01	2.0000D-02	19	8	25
20	9	10	3.0000D 07	1.4160D-01	1.1000D 07	9.0900D-02	6.6000D-02	2.4900D-02	2.6160D 01	2.0000D-02	20	9	10
21	9	11	3.0000D 07	1.4160D-01	1.1000D 07	9.0900D-02	6.6000D-02	2.4900D-02	2.9000D 01	2.0000D-02	21	9	11
22	9	13	3.0000D 07	6.9400D-02	1.1000D 07	7.2000D-01	3.6000D-01	3.6000D-01	2.8563D 01	2.0000D-02	22	9	13
23	9	14	3.0000D 07	1.0790D-01	1.1000D 07	1.3400D-02	6.7000D-03	6.7000D-03	1.6594D 01	2.0000D-02	23	9	14
24	10	12	3.0000D 07	1.4160D-01	1.1000D 07	9.0900D-02	6.6000D-02	2.4900D-02	2.9000D 01	2.0000D-02	24	10	12
25	10	13	3.0000D 07	6.9400D-02	1.1000D 07	7.2000D-01	3.6000D-01	3.6000D-01	2.3775D 01	2.0000D-02	25	10	13
26	10	14	3.0000D 07	1.0790D-01	1.1000D 07	1.3400D-02	6.7000D-03	6.7000D-03	3.3604D 01	2.0000D-02	26	10	14
27	11	12	3.0000D 07	1.4160D-01	1.1000D 07	9.0900D-02	6.6000D-02	2.4900D-02	2.6160D 01	2.0000D-02	27	11	12
28	11	13	3.0000D 07	6.9400D-02	1.1000D 07	7.2000D-01	3.6000D-01	3.6000D-01	2.8563D 01	2.0000D-02	28	11	13
29	11	14	3.0000D 07	1.0790D-01	1.1000D 07	1.3400D-02	6.7000D-03	6.7000D-03	1.6594D 01	2.0000D-02	29	11	14
30	11	16	1.0500D 07	1.8760D-01	4.0000D 06	1.1160D-01	3.4400D-02	7.7400D-02	2.1156D 01	2.0000D-02	30	11	16
31	12	13	3.0000D 07	6.9400D-02	1.1000D 07	7.2000D-01	3.6000D-01	3.6000D-01	2.3775D 01	2.0000D-02	31	12	13
32	12	14	3.0000D 07	1.0790D-01	1.1000D 07	1.3400D-02	6.7000D-03	6.7000D-03	3.3604D 01	2.0000D-02	32	12	14
33	12	17	1.0500D 07	2.4530D-01	4.0000D 06	2.6630D-01	1.8000D-02	2.4830D-01	2.4106D 01	2.0000D-02	33	12	17
34	15	16	1.0500D 07	6.3880D-01	4.0000D 06	1.6113D 00	1.5740D 00	3.7300D-02	1.6280D 01	2.0000D-02	34	15	16
35	16	17	1.0500D 07	8.5850D-01	4.0000D 06	2.6255D 00	5.9860D-01	2.0269D 00	2.4293D 01	2.0000D-02	35	16	17
36	16	19	1.0500D 07	1.4750D-01	4.0000D 06	8.9960D 01	4.1760D 01	4.8220D 01	3.2280D 01	2.0000D-02	36	16	19
37	16	24	1.0500D 07	6.4700D-01	4.0000D 06	2.3331D 00	1.8686D 00	4.6450D-01	7.9917D 01	2.0000D-02	37	16	24
38	17	18	1.0500D 07	8.5850D-01	4.0000D 06	2.6255D 00	5.9860D-01	2.0269D 00	2.0476D 01	2.0000D-02	38	17	18
39	18	20	1.0500D 07	6.7270D-01	4.0000D 06	1.9791D 01	1.5000D 01	4.7910D 00	3.1006D 01	2.0000D-02	39	18	20
40	18	24	1.0500D 07	1.5830D 00	4.0000D 06	2.3288D 02	1.6380D 01	2.1650D 02	6.0998D 01	2.0000D-02	40	18	24
41	19	20	1.0500D 07	5.0460D-01	4.0000D 06	7.4380D-01	3.7000D-01	3.7380D-01	4.5673D 01	2.0000D-02	41	19	20
42	19	21	1.0500D 07	8.1640D-01	4.0000D 06	6.6600D 01	2.7430D 01	3.9230D 01	4.2635D 01	2.0000D-02	42	19	21
43	19	27	1.0500D 07	2.4410D 00	4.0000D 06	4.0348D 01	1.4070D 01	2.6278D 01	1.4000D 01	2.0000D-02	43	19	27
44	20	22	1.0500D 07	1.8100D-01	4.0000D 06	1.5730D-01	9.5100D-02	6.2200D-02	4.1711D 01	2.0000D-02	44	20	22
45	21	22	1.0500D 07	1.5280D-01	4.0000D 06	1.2090D-01	1.1260D-01	8.3000D-03	2.1151D 01	2.0000D-02	45	21	22
46	21	29	1.0500D 07	1.5280D-01	4.0000D 06	1.2090D-01	1.1260D-01	8.3000D-03	1.2000D 01	2.0000D-02	46	21	29
47	21	32	1.0500D 07	6.0000D-01	4.0000D 06	7.0000D 00	3.5000D 00	3.5000D 00	1.0747D 02	2.0000D-02	47	21	32
48	22	31	1.0500D 07	1.5280D-01	4.0000D 06	1.2090D-01	1.1260D-01	8.3000D-03	2.4500D 01	2.0000D-02	48	22	31
49	22	32	1.0500D 07	6.0000D-01	4.0000D 06	8.5000D 00	3.5000D 00	5.0000D 00	1.0616D 02	2.0000D-02	49	22	32
50	23	24	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	1.0973D 02	2.0000D-02	50	23	24
51	25	26	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	1.0973D 02	2.0000D-02	51	25	26
52	27	28	3.0000D 07	4.0000D-01	1.1000D 07	2.0339D 01	1.4965D 01	5.3540D 00	1.2000D 01	2.0000D-02	52	27	28
53	29	30	1.0500D 07	1.1370D-01	4.0000D 06	7.5500D-02	6.9600D-02	5.9000D-03	1.2000D 01	2.0000D-02	53	29	30
54	30	31	1.0500D 07	1.1370D-01	4.0000D 06	7.5500D-02	6.9600D-02	5.9000D-03	2.1151D 01	2.0000D-02	54	30	31
55	30	32	1.0500D 07	6.0000D-01	4.0000D 06	7.0000D 00	3.5000D 00	3.5000D 00	1.0747D 02	2.0000D-02	55	30	32
56	31	32	1.0500D 07	6.0000D-01	4.0000D 06	8.5000D 00	3.5000D 00	5.0000D 00	1.0616D 02	2.0000D-02	56	31	32
57	27	29	1.0500D 07	1.4750D 00	4.0000D 06	6.6730D 01	2.7430D 01	3.9300D 01	4.2589D 01	2.0000D-02	57	27	29
58	15	27	1.0500D 07	1.4750D 00	4.0000D 06	6.6730D 01	2.7430D 01	3.9300D 01	3.2149D 01	2.0000D-02	58	15	27
59	20	33	1.0500D 07	1.5830D 00	4.0000D 06	2.3288D 02	1.6380D 01	2.1650D 02	6.7469D 01	2.0000D-02	59	20	33
60	23	33	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	1.0975D 02	2.0000D-02	60	23	33
61	26	34	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	1.0975D 02	2.0000D-02	61	26	34
62	5	34	1.0500D 07	1.5830D 00	4.0000D 06	2.3288D 02	1.6380D 01	2.1650D 02	6.7469D 01	2.0000D-02	62	5	34
63	24	33	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	2.2000D 00	2.0000D-02	63	24	33
64	25	34	0.0	1.0000D 00	0.0	2.0000D 00	1.0000D 00	1.0000D 00	2.2000D 00	2.0000D-02	64	25	34
65	7	9	1.0500D 07	2.0000D-01	4.0000D 06	0.0	0.0	0.0	3.5573D 01	2.0000D-02	65	7	9
66	11	17	1.0500D 07	2.0000D-01	4.0000D 06	0.0	0.0	0.0	3.5573D 01	2.0000D-02	66	11	17
67	5	30	1.0500D 07	2.0000D-01	4.0000D 06	0.0	0.0	0.0	5.3535D 01	2.0000D-02	67	5	30
68	20	21	1.0500D 07	2.0000D-01	4.0000D 06	0.0	0.0	0.0	5.3535D 01	2.0000D-02	68	20	21
69	28	35	1.0500D 07	2.2520D-03	4.0000D 06	2.0000D 00	1.0000D 00	1.0000D 00	1.7000D 01	1.9460D-01	69	28	35

Figure C-3 Airplane A 35 Mass, 69 Member Math Model Member Property Data

DAMPING TERMS (LB/IN/SEC,TRANSLATIONS (1)-(3) AND LB-IN-SEC,ROTATIONS (4)-(6))

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	14	0.0	0.0	0.0	0.0	0.0	0.0
2	2	4	1.960550 01	2.706690 00	4.100110-01	1.134390 02	4.516650 01	3.541050 02
3	3	19	1.960550 01	2.706690 00	4.100110-01	1.134390 02	4.516650 01	3.617600 02
4	4	5	5.859240 00	3.872250-01	3.602770-01	7.665970 01	1.952730 02	1.802860 02
5	4	6	3.016110 00	5.856150 00	5.449780 00	3.450910 02	1.218470 03	1.335680 03
6	4	27	2.656650 01	2.156790 01	1.578190 01	4.362920 02	6.716700 02	1.145340 03
7	4	30	5.457550 00	3.073800 00	2.570270 00	2.451690 02	1.050470 03	1.237260 03
8	5	6	9.562780 00	2.851030 00	5.044680 00	7.494410 02	1.851730 03	1.096850 03
9	5	20	6.456080 00	4.746960-01	4.441090-01	9.798950 01	2.717190 02	2.416560 02
10	5	31	3.216120 00	1.566730-01	1.937270-01	4.205820 01	1.010110 02	8.403400 01
11	6	7	7.784770 00	1.705660 00	9.269250-01	1.277040 02	1.934470 02	2.370460 02
12	6	9	4.047450 00	4.256910-01	2.837940-01	2.630010 01	4.958880 01	7.128480 01
13	6	15	9.505070 00	4.887240-01	3.174870 00	1.338690 02	2.817560 02	6.770200 01
14	6	25	6.666460 00	2.065670-01	4.163230-01	1.410920 02	6.592760 02	3.742150 02
15	7	8	1.141040 01	2.965870 00	1.611790 00	2.515330 02	4.085390 02	7.045440 02
16	7	10	4.335790 00	6.266690-01	1.667820-01	2.423010 01	3.361770 01	1.198450 02
17	7	17	0.0	0.0	0.0	0.0	0.0	0.0
18	8	18	7.436260 00	5.074670-01	4.747660-01	1.105710 02	2.913520 02	2.753830 02
19	8	25	1.180940 01	7.843210 00	2.157350 00	1.620350 03	3.155270 03	1.163250 04
20	9	10	5.533500 00	3.072700-01	5.002570-01	3.290060 01	1.045380 02	5.103870 01
21	9	11	5.255570 00	2.632570-01	4.286000-01	3.527840 01	7.892090 01	5.401790 01
22	9	13	9.524520 00	2.630640 00	2.630840 00	1.165170 02	4.321290 02	4.429400 02
23	9	14	5.961060 00	3.100920-01	3.100920-01	1.357490 01	2.855340 01	2.712560 01
24	10	12	5.255570 00	2.632570-01	4.286000-01	3.527840 01	7.892090 01	5.401790 01
25	10	13	1.643970 01	3.464370 00	3.464370 00	2.604030 02	4.736490 02	4.941990 02
26	10	14	4.188940 00	1.076050-01	1.076050-01	8.468380 00	2.006490 01	2.190440 01
27	11	12	5.533500 00	3.072700-01	5.002570-01	3.290060 01	1.045380 02	5.103870 01
28	11	13	9.524520 00	2.630640 00	2.630840 00	1.165170 02	4.321290 02	4.415820 02
29	11	14	5.961060 00	3.100920-01	3.100920-01	1.357490 01	2.855340 01	2.708150 01
30	11	16	4.047450 00	4.256910-01	2.837940-01	2.630010 01	4.958880 01	7.128210 01
31	12	13	1.643970 01	3.464370 00	3.464370 00	2.604030 02	4.736490 02	4.938460 02
32	12	14	4.188940 00	1.076050-01	1.076050-01	8.468380 00	2.006490 01	2.135630 01
33	12	17	4.335790 00	6.266690-01	1.667820-01	2.423010 01	3.361770 01	1.199450 02
34	15	16	9.505070 00	4.887240-01	3.174770 00	1.338650 02	2.817470 02	6.770200 01
35	16	17	7.784770 00	1.705660 00	9.269250-01	1.277040 02	1.934470 02	2.375480 02
36	16	19	3.018110 00	5.856150 00	5.449780 00	3.450910 02	1.218470 03	1.335700 03
37	16	24	6.666460 00	2.065670-01	4.163230-01	1.410920 02	6.592760 02	3.751880 02
38	17	18	1.141040 01	2.965870 00	1.611790 00	2.515330 02	4.085390 02	7.010480 02
39	18	20	9.562780 00	2.851030 00	5.044680 00	7.494410 02	1.851730 03	1.096850 03
40	18	24	1.180940 01	7.843210 00	2.157350 00	1.620350 03	3.155270 03	1.163250 04
41	19	20	5.859240 00	3.872250-01	3.602770-01	7.665970 01	1.952730 02	1.784760 02
42	19	21	5.457550 00	3.073800 00	2.570270 00	2.451690 02	1.050470 03	1.237340 03
43	19	27	2.656650 01	2.156790 01	1.578190 01	4.362920 02	6.716700 02	1.145340 03
44	20	22	3.216120 00	1.566730-01	1.937270-01	4.205820 01	1.010110 02	8.437440 01
45	21	22	2.461780 00	4.556730-02	3.461040-01	3.786060 01	3.286900 01	3.227390 01
46	21	29	5.245010 00	5.622810-01	1.299760 00	4.177110 01	1.018150 02	4.062130 01
47	21	32	4.212830 00	3.275690-01	3.279650-01	1.107400 02	3.430660 02	3.663200 02
48	22	31	2.717370 00	7.557700-02	2.776320-01	3.531980 01	3.056040 01	2.931490 01
49	22	32	4.238810 00	2.992540-01	3.340730-01	1.210580 02	3.451370 02	4.435110 02
50	23	24	0.0	0.0	0.0	0.0	0.0	0.0
51	25	26	0.0	0.0	0.0	0.0	0.0	0.0
52	27	28	3.245490 01	3.427670 01	5.734400 01	6.843530 02	1.638650 03	1.022360 03
53	29	30	4.034441 00	2.975230-01	1.621880 00	2.00430 01	8.004700 01	3.374750 01
54	30	31	2.124530 00	7.422510-02	2.721090-01	3.487170 01	2.584181 01	2.721060 01
55	30	32	4.212830 00	3.275690-01	3.279690-01	1.107400 02	3.430660 02	3.663620 02
56	31	32	4.238810 00	2.992540-01	3.340730-01	1.210580 02	3.451370 02	4.425100 02
57	27	29	1.269440 01	5.329780 00	4.452730 00	4.34780 02	7.149510 02	1.096160 03
58	19	27	1.412740 01	7.649270 00	6.554270 00	3.688060 02	1.109160 03	1.353410 03
59	20	33	1.036481 01	6.223560 00	1.711040 00	1.104460 03	2.532790 03	1.006400 04
60	23	33	0.0	0.0	0.0	0.0	0.0	0.0
61	26	34	0.0	0.0	0.0	0.0	0.0	0.0
62	5	34	1.036480 01	6.223560 00	1.711840 00	1.104460 03	2.532790 03	1.006400 04
63	24	33	0.0	0.0	0.0	0.0	0.0	0.0
64	25	34	0.0	0.0	0.0	0.0	0.0	0.0
65	7	9	3.222820 00	0.0	0.0	0.0	0.0	0.0
66	11	17	3.222820 00	0.0	0.0	0.0	0.0	0.0
67	5	30	3.657060 00	0.0	0.0	0.0	0.0	0.0
68	20	21	3.657060 00	0.0	0.0	0.0	0.0	0.0
69	28	35	1.328250 01	5.703400 01	5.703400 01	1.016600 03	1.972830 03	2.231000 03

Figure C-4 Airplane A 35 Mass, 69 Member Math Model Damping Data

BEAM UNCOUPLED,UNDAMPED FREQUENCIES (CPS)

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	14	0.0	0.0	0.0	0.0	0.0	0.0
2	2	4	6.5625D 02	8.4693D 01	1.3586D 01	7.7998D 01	2.9956D 01	2.1068D 02
3	3	19	6.5625D 02	8.4693D 01	1.3586D 01	7.7998D 01	2.9956D 01	2.1068D 02
4	4	5	1.2613D 02	8.2337D 00	8.1918D 00	4.6418D 00	1.2847D 01	1.2436D 01
5	4	6	1.0121D 02	1.4637D 02	1.8275D 02	1.8036D 02	2.8354D 02	2.9680D 02
6	4	27	4.3672D 02	3.5617D 02	2.6062D 02	2.0408D 02	3.2180D 02	4.3819D 02
7	4	30	2.3454D 02	1.3210D 02	1.1046D 02	1.7305D 02	1.6361D 02	1.9620D 02
8	5	6	1.5165D 02	4.5213D 01	8.0001D 01	2.0372D 01	6.9850D 01	3.7668D 01
9	5	20	1.1619D 02	8.0655D 00	7.5456D 00	3.3542D 00	9.3004D 00	9.5369D 00
10	5	31	9.0137D 01	4.3863D 00	5.4261D 00	2.2676D 00	6.0554D 00	4.7630D 00
11	6	7	3.0345D 02	6.6486D 01	3.6131D 01	3.3427D 01	3.4058D 01	6.1070D 01
12	6	9	1.4645D 02	1.5403D 01	1.0269D 01	6.6723D 00	8.7528D 00	1.3696D 01
13	6	15	2.7595D 02	1.4184D 01	9.2173D 01	2.8650D 01	6.0300D 01	9.0486D 00
14	6	25	1.1221D 02	3.5002D 00	7.0203D 00	2.5010D 00	2.3079D 01	3.4688D 00
15	7	8	2.4561D 02	6.3840D 01	3.4694D 01	1.2109D 01	2.1020D 01	3.6697D 01
16	7	10	1.5689D 02	2.2683D 01	6.1072D 00	9.6471D 00	5.9314D 00	2.2981D 01
17	7	17	0.0	0.0	0.0	0.0	0.0	0.0
18	8	16	1.1056D 02	7.5447D 00	7.0585D 00	3.1282D 00	8.2426D 00	8.3766D 00
19	8	25	1.4690D 02	9.7563D 01	2.6836D 01	2.6479D 01	5.4969D 01	8.1574D 01
20	9	10	1.6683D 02	1.0374D 01	1.6890D 01	8.2416D 00	1.8437D 01	1.2785D 01
21	9	11	1.7744D 02	8.8883D 00	1.4471D 01	7.8276D 00	1.7511D 01	1.2143D 01
22	9	13	4.8721D 01	1.3458D 01	1.3458D 01	1.0385D 01	2.1105D 01	2.1189D 01
23	9	14	2.0833D 02	1.0837D 01	1.0837D 01	4.8395D 00	9.3562D 00	1.1468D 01
24	10	12	1.7744D 02	8.8883D 00	1.4471D 01	7.8276D 00	1.7511D 01	1.2143D 01
25	10	13	5.3402D 01	1.7721D 01	1.7721D 01	1.1363D 01	2.3133D 01	2.3225D 01
26	10	14	1.4140D 02	3.7607D 00	3.7607D 00	3.4008D 00	6.5748D 00	8.0587D 00
27	11	12	1.6683D 02	1.0374D 01	1.6890D 01	8.2416D 00	1.8437D 01	1.2785D 01
28	11	13	4.8721D 01	1.3458D 01	1.3458D 01	1.0385D 01	2.1105D 01	2.1189D 01
29	11	14	2.0833D 02	1.0837D 01	1.0837D 01	4.8395D 00	9.3562D 00	1.1468D 01
30	11	16	1.4645D 02	1.5403D 01	1.0269D 01	6.6723D 00	8.7528D 00	1.3696D 01
31	12	13	5.3402D 01	1.7721D 01	1.7721D 01	1.1363D 01	2.3133D 01	2.3225D 01
32	12	14	1.4140D 02	3.7607D 00	3.7607D 00	3.4008D 00	6.5748D 00	8.0587D 00
33	12	17	1.5689D 02	2.2683D 01	6.1072D 00	9.6471D 00	5.9314D 00	2.2981D 01
34	15	16	2.7595D 02	1.4184D 01	9.2171D 01	2.8649D 01	6.0258D 01	9.0486D 00
35	16	17	3.0345D 02	6.6486D 01	3.6131D 01	3.3427D 01	3.4058D 01	6.1070D 01
36	16	19	1.0121D 02	1.4637D 02	1.8275D 02	1.8036D 02	2.8354D 02	2.9880D 02
37	16	24	1.1221D 02	3.5002D 00	7.0203D 00	2.5010D 00	2.3079D 01	3.4688D 00
38	17	18	2.4561D 02	6.3840D 01	3.4694D 01	1.2109D 01	2.1020D 01	3.6897D 01
39	18	20	1.5165D 02	4.5213D 01	8.0001D 01	2.0372D 01	6.9850D 01	3.7668D 01
40	18	24	1.4690D 02	9.7563D 01	2.6836D 01	2.6479D 01	5.4989D 01	8.1574D 01
41	19	20	1.2613D 02	8.2337D 00	8.1918D 00	4.6418D 00	1.2847D 01	1.2436D 01
42	19	21	2.3454D 02	1.3210D 02	1.1046D 02	1.7305D 02	1.6361D 02	1.9620D 02
43	19	27	4.3672D 02	3.5617D 02	2.6062D 02	2.0408D 02	3.2186D 02	4.3819D 02
44	20	22	9.0137D 01	4.3863D 00	5.4261D 00	2.2676D 00	6.0554D 00	4.7630D 00
45	21	22	1.9016D 02	7.4776D 00	[illegible].7579D 01	1.3846D 01	1.1974D 01	3.7642D 00
46	21	29	1.7226D 02	1.4919D 01	4.0216D 01	7.8759D 00	1.9207D 01	4.6210D 00
47	21	32	6.8566D 01	6.6564D 00	6.9665D 00	1.5295D 01	2.5304D 01	2.3603D 01
48	22	31	1.0226D 02	6.0062D 00	2.2172D 01	1.2867D 01	1.1126D 01	3.0376D 00
49	22	32	8.9133D 01	[illegible]	7.0246D 00	1.6958D 01	2.5466D 01	2.8385D 01
50	23	24	0.0	0.0	0.0	0.0	0.0	0.0
51	25	26	0.0	0.0	0.0	0.0	0.0	0.0
52	27	28	1.9416D 02	2.6717D 02	3.4655D 02	1.9675D 02	5.8216D 02	2.9391D 02
53	29	30	1.5999D 02	9.7056D 00	3.1615D 01	6.2270D 00	1.5101D 01	3.6470D 00
54	30	31	1.6421D 02	6.4124D 00	2.1662D 01	1.0943D 01	9.4141D 00	2.7563D 00
55	30	32	8.6556D 01	[illegible]	[illegible]	1.5245D 01	2.5764D 01	2.3603D 01
56	31	32	8.9133D 01	8.2963D 00	7.0246D 00	1.6958D 01	2.5466D 01	2.8385D 01
57	27	29	1.2236D 02	7.6572D 01	6.3471D 01	5.4366D 01	2.4017D 02	2.2476D 02
58	15	27	2.1679D 02	1.2037D 02	[illegible] 02	1.4355D 02	2.0536D 02	2.4093D 02
59	20	33	1.5132D 02	9.0861D 01	2.4492D 01	2.7460D 01	5.6063D 01	8.5235D 01
60	23	33	0.0	0.0	0.0	0.0	0.0	0.0
61	26	34	0.0	0.0	0.0	0.0	0.0	0.0
62	5	34	1.5132D 02	9.0861D 01	2.4492D 01	2.7460D 01	5.6063D 01	8.5235D 01
63	24	33	0.0	0.0	0.0	0.0	0.0	0.0
64	25	34	0.0	0.0	0.0	0.0	0.0	0.0
65	7	9	1.1662D 02	0.0	0.0	0.0	0.0	0.0
66	11	17	1.1662D 02	0.0	0.0	0.0	0.0	0.0
67	5	30	1.0243D 02	0.0	0.0	0.0	0.0	0.0
68	20	21	1.0243D 02	0.0	0.0	0.0	0.0	0.0
69	28	35	6.4168D 00	2.7854D 01	2.7854D 01	2.9937D 01	7.7572D 01	6.5690D 01

Figure C-5 Airplane A 35 Mass, 69 Member Math Model Frequency Data

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VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

        XGDOT              YGDOT              ZGDOT
          P*                 Q*                 R*
         PHI*              THETA*              PSI*

      5.400000D 02       0.0                0.0
      0.0                0.0                0.0
      0.0                0.0                0.0

GENERALIZED SURFACE DATA

BETA =  45.0 DEGREES
XGIN =   0.0
ZGIN =   0.0


MODEL PARAMETERS

VEHICLE WT = 1.601829D 03

VEHICLE CG POSITION
X (FS) =  3.65220D 01
Y (BL) =  5.67786D-16
Z (WL) =  3.38246D 00

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 9.43552D 03
I(YY) = 1.02132D 04
I(ZZ) = 1.65440D 04

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG = -2.97024D 01
ZCG = -4.29735D 01
```

Figure C-6 Airplane A 35 Mass, 69 Member Math Model Initial Conditions, Overall Mass and c.g. Properties

MASS DATA

	WEIGHTS	MASS COORDINATES F.S.,W.L.,B.L.			MASS MOMENTS OF INERTIA (LB-IN-SEC**2)			
I	W	X**	Y**	Z**	IX	IY	IZ	I
1	1.63000D 01	-1.07500D 01	0.0	-3.45900D 01	6.40000D-01	1.41000D 00	6.40000D-01	1
2	2.02500D 01	4.76000D 01	3.97900D 01	-3.45900D 01	8.12000D-01	1.79700D 00	8.12000D-01	2
3	2.02500D 01	4.76000D 01	-3.97900D 01	-3.45900D 01	8.12000D-01	1.79700D 00	8.12000D-01	3
4	1.19100D 02	5.31300D 01	0.0	-1.74400D 01	1.40400D 01	2.03000D 01	1.81800D 01	4
5	9.03900D 01	5.31300D 01	0.0	2.54400D 01	1.81900D 02	1.15940D 02	1.25680D 02	5
6	7.26000D 01	2.09800D 01	0.0	-1.56600D 01	1.45860D 01	3.38400D 01	3.56000D 01	6
7	3.94000D 01	2.40400D 01	0.0	6.44000D 00	1.45860D 01	3.38400D 01	3.56000D 01	7
8	1.03300D 02	2.65200D 01	0.0	2.61500D 01	1.98340D 02	1.39000D 02	1.54720D 02	8
9	4.54500D 01	0.0	0.0	-1.77200D 01	1.42540D 01	2.25600D 01	1.77000D 01	9
10	4.54500D 01	0.0	0.0	6.44000D 00	1.42540D 01	2.25600D 01	1.77000D 01	10
11	5.92700D 01	9.50000D 01	0.0	-4.65000D 00	3.02000D 00	3.90400D 01	3.90400D 01	11
12	1.92700D 01	9.50000D 01	0.0	9.50000D 00	3.02000D 00	3.90400D 01	3.90400D 01	12
13	2.77490D 02	-1.69200D 01	0.0	-1.85000D 00	5.60000D 01	7.47300D 01	7.64800D 01	13
14	2.12000D 01	-7.39000D 00	0.0	-2.24000D 01	2.48000D 00	2.74000D 00	4.80000D-01	14
15	1.31800D 02	2.65200D 01	8.22400D 01	2.71200D 01	8.59000D 02	6.56000D 01	9.21500D 02	15
16	1.31800D 02	2.65200D 01	-8.22400D 01	2.71200D 01	8.59000D 02	6.56000D 01	9.21500D 02	16
17	6.34000D 01	2.00380D 02	0.0	5.70000D 00	2.67000D 01	3.43600D 01	4.26600D 01	17
18	1.87200D 02	5.31300D 01	0.0	-5.44000D 00	9.30000D 00	6.70000D 00	1.12000D 01	18
19	3.90000D 00	2.65200D 01	1.91970D 02	2.71200D 01	4.50000D-01	1.78000D 00	2.15000D 00	19
20	3.90000D 00	2.65200D 01	-1.91970D 02	2.71200D 01	4.50000D-01	1.78000D 00	2.15000D 00	20
21	1.36000D 02	5.31300D 01	0.0	1.15600D 01	4.00000D 00	3.70000D 00	3.30000D 00	21

Figure C-7. Airplane A 21 Mass, 32 Member, Math Model Mass Data

INTERNAL BEAM DATA

BEAM			MODULUS OF ELASTICITY	AREA	MODULUS OF RIGIDITY	MOMENTS OF INERTIA			LENGTH	DAMPING RATIO	BEAM		
IJ	I	J	E	A	G	JX	I(YY)	I(ZZ)	XLP	CBAR	IJ	I	J
1	1	14	3.0000D 07	7.2810D-02	1.1000D 07	1.1330D-01	5.6680D-02	5.6680D-02	1.2106D 01	2.0000D-02	1	1	14
2	2	4	3.0000D 07	2.0700D 00	1.1000D 07	3.0497D 00	6.8400D-02	2.9813D 00	4.3680D 01	2.0000D-02	2	2	4
3	3	4	3.0000D 07	2.0700D 00	1.1000D 07	3.0497D 00	6.8400D-02	2.9813D 00	4.3680D 01	2.0000D-02	3	3	4
4	4	5	1.0500D 07	1.0920D 00	4.0000D 06	1.4876D 00	7.4000D-01	7.4760D-01	4.2880D 01	2.0000D-02	4	4	5
5	4	6	1.0500D 07	2.9500D-01	4.0000D 06	1.7996D 02	8.3520D 01	9.6440D 01	3.2199D 01	2.0000D-02	5	4	6
6	4	11	1.0500D 07	1.6200D 00	4.0000D 06	1.3332D 02	5.4860D 01	7.8460D 01	4.2589D 01	2.0000D-02	6	4	11
7	5	8	1.0500D 07	1.3400D 00	4.0000D 06	3.9600D 01	3.0000D 01	9.6000D 00	2.6619D 01	2.0000D-02	7	5	8
8	5	12	1.0500D 07	3.6200D-01	4.0000D 06	3.1400D-01	1.9000D-01	1.2400D-01	4.4802D 01	2.0000D-02	8	5	12
9	6	7	1.0500D 07	1.7170D 00	4.0000D 06	5.2600D 00	1.2000D 00	4.0600D 00	2.2311D 01	2.0000D-02	9	6	7
10	6	9	1.0500D 07	3.7500D-01	4.0000D 06	2.2360D-01	6.8800D-02	1.5480D-01	2.1081D 01	2.0000D-02	10	6	9
11	7	8	1.0500D 07	1.7170D 00	4.0000D 06	5.2540D 00	1.2000D 00	4.0540D 00	1.9865D 01	2.0000D-02	11	7	8
12	7	10	1.0500D 07	4.9000D-01	4.0000D 06	5.3260D-01	3.6000D-02	4.9660D-01	2.4040D 01	2.0000D-02	12	7	10
13	8	15	1.0500D 07	3.1650D 00	4.0000D 06	4.6582D 02	3.2750D 01	4.3307D 02	8.2246D 01	2.0000D-02	13	8	15
14	8	16	1.0500D 07	3.1650D 00	4.0000D 06	4.6582D 02	3.2750D 01	4.3307D 02	8.2246D 01	2.0000D-02	14	8	16
15	9	10	3.0000D 07	2.9200D-01	1.1000D 07	1.6200D-01	1.3200D-01	5.0000D-02	2.4160D 01	2.0000D-02	15	9	10
16	9	13	3.0000D 07	1.4000D-01	1.1000D 07	1.4400D 00	7.2000D-01	7.2000D-01	2.3198D 01	2.0000D-02	16	9	13
17	9	14	3.0000D 07	2.1600D-01	1.1000D 07	2.6800D-02	1.3400D-02	1.3400D-02	9.0592D 00	2.0000D-02	17	9	14
18	10	13	3.0000D 07	1.4000D-01	1.1000D 07	1.4400D 00	7.2000D-01	7.2000D-01	1.6842D 01	2.0000D-02	18	10	13
19	10	14	3.0000D 07	2.1600D-01	1.1000D 07	2.6800D-02	1.3400D-02	1.3400D-02	3.0315D 01	2.0000D-02	19	10	14
20	11	12	1.0500D 07	2.2740D-01	4.0000D 06	1.5200D-01	1.4000D-01	1.2000D-02	1.9150D 01	2.0000D-02	20	11	12
21	11	17	1.0500D 07	6.0000D-01	4.0000D 06	1.4000D 01	7.0000D 00	7.0000D 00	1.0649D 02	2.0000D-02	21	11	17
22	12	17	1.0500D 07	6.0000D-01	4.0000D 06	1.7000D 01	7.0000D 00	1.0000D 01	1.0545D 02	2.0000D-02	22	12	17
23	4	18	3.0000D 07	4.0000D-01	1.1000D 07	2.0300D 01	1.5000D 01	5.3000D 00	1.2000D 01	2.0000D-02	23	4	18
24	6	15	1.0500D 07	1.7940D 00	4.0000D 06	2.3320D 00	0.0	4.6500D-01	9.2867D 01	2.0000D-02	24	6	15
25	6	16	1.0500D 07	1.7940D 00	4.0000D 06	2.3320D 00	0.0	4.6500D-01	9.2867D 01	2.0000D-02	25	6	16
26	15	19	1.0500D 07	3.0980D 00	4.0000D 06	2.6068D 02	1.9920D 01	2.4076D 02	1.0973D 02	2.0000D-02	26	15	19
27	16	20	1.0500D 07	3.0980D 00	4.0000D 06	2.6068D 02	1.9920D 01	2.4076D 02	1.0973D 02	2.0000D-02	27	16	20
28	5	20	1.0500D 07	3.0980D 00	4.0000D 06	3.6340D 02	2.6400D 01	3.3700D 02	1.9381D 02	2.0000D-02	28	5	20
29	5	19	1.0500D 07	3.0980D 00	4.0000D 06	3.6340D 02	2.6400D 01	3.3700D 02	1.9381D 02	2.0000D-02	29	5	19
30	7	9	1.0500D 07	4.0000D-01	4.0000D 06	0.0	0.0	0.0	3.4083D 01	2.0000D-02	30	7	9
31	16	21	1.0500D 07	2.2520D-03	5.0000D 06	2.0000D 00	1.0000D 00	1.0000D 00	1.7000D 01	1.9460D-01	31	18	21
32	5	11	1.0500D 07	6.0000D-01	4.0000D 06	0.0	0.0	0.0	5.4630D 01	2.0000D-02	32	5	11

Figure C-8. Airplane A 21 Mass, 32 Member, Math Model Member Property Data

DAMPING TERMS (LB/IN/SEC,TRANSLATIONS (1)-(3) AND LB-IN-SEC,ROTATIONS (4)-(6))

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	14	4.25395D 00	1.22551D 00	1.22551D 00	1.44907D 01	6.10795D 01	5.16359D 01
2	2	4	2.66573D 01	2.72747D 00	4.13129D-01	1.62549D 02	6.71317D 01	5.04581D 02
3	3	4	2.66573D 01	2.72747D 00	4.13129D-01	1.62549D 02	6.71317D 01	5.05127D 02
4	4	5	1.52264D 01	1.01658D 00	1.01339D 00	1.78721D 02	3.97409D 02	4.74130D 02
5	4	6	8.74323D 00	1.70073D 01	1.58271D 01	1.01325D 03	3.07146D 03	3.28769D 03
6	4	11	1.72378D 01	9.72768D 00	8.13417D 00	6.07216D 02	2.26642D 03	2.63013D 03
7	5	6	2.46005D 01	7.17552D 00	1.26846D 01	1.50251D 03	4.39405D 03	2.60714D 03
8	5	12	6.21018D 00	2.81054D-01	3.47876D-01	9.04433D 01	2.10161D 02	1.76387D 02
9	6	7	1.53691D 01	4.62446D 00	2.51414D 00	3.25942D 02	4.94542D 02	6.06312D 02
10	6	9	9.56203D 00	1.00954D 00	6.73024D-01	4.44253D 01	1.11218D 02	1.61821D 02
11	7	8	2.31697D 01	6.20827D 00	3.37771D 00	5.68129D 02	8.37611D 02	1.76738D 03
12	7	10	8.67624D 00	1.25891D 00	3.36954D-01	6.39471D 01	7.53370D 01	2.72010D 02
13	8	15	1.91440D 01	5.77684D 00	2.66859D 00	2.72411D 03	5.31913D 03	1.95134D 04
14	8	16	1.92440D 01	9.77624D 00	2.66859D 00	2.72411D 03	5.31913D 03	1.95134D 04
15	9	10	1.16438D 01	6.93812D-01	1.12731D 00	6.85086D 01	2.17557D 02	1.06432D 02
16	9	13	1.55692D 01	5.27242D 00	5.27242D 00	3.05249D 02	7.61424D 02	7.07165D 02
17	9	14	1.46621D 01	1.33924D 00	1.33924D 00	2.99410D 01	8.47652D 01	7.08921D 01
18	10	13	1.72755D 01	7.20281D 00	7.20281D 00	3.20777D 02	8.44872D 02	8.12311D 02
19	10	14	7.66725D 00	2.18794D-01	2.18794D-01	1.67790D 01	4.63380D 01	3.77824D 01
20	11	12	6.37131D 00	2.64776D-01	9.04314D-01	6.29792D 01	1.95855D 02	1.59481D 01
21	11	17	5.48477D 00	6.09404D-01	6.09404D-01	1.60980D 02	5.69407D 02	5.96755D 02
22	12	17	4.52483D 00	6.06843D-01	5.07721D-01	1.75312D 02	5.72218D 02	7.21267D 02
23	4	18	3.56525D 01	5.74428D 01	6.29907D 01	4.35276D 02	2.54558D 03	1.40685D 03
24	6	15	1.31697D 01	2.41966D-01	0.0	2.13760D 02	0.0	5.10941D 02
25	6	16	1.31697D 01	2.48566D-01	0.0	2.13760D 02	0.0	5.10932D 02
26	15	19	1.29134D 01	3.54303D 00	1.03374D 00	1.01215D 03	3.23800D 03	1.16699D 04
27	16	20	1.29134D 01	3.59383D 00	1.03374D 00	1.01215D 03	3.23800D 03	1.16699D 04
28	5	20	8.09944D 00	1.50986D 00	4.22595D-01	1.19469D 03	1.28763D 03	3.86477D 03
29	5	19	8.09944D 00	1.50986D 00	4.22595D-01	1.19469D 03	1.28763D 03	3.86477D 03
30	7	9	6.33612D 00	0.0	0.0	0.0	0.0	0.0
31	18	21	1.32825D 01	5.70346D 01	5.70346D 01	1.13666D 03	1.97283D 03	2.23100D 03
32	5	11	6.45837D 00	0.0	0.0	0.0	0.0	0.0

Figure C-9. Airplane A 21 Mass, 32 Member, Math Model Damping Data

BEAM UNCOUPLED,UNDAMPED FREQUENCIES (CPS)

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	14	2.3066D 02	5.9751D 01	5.9751D 01	2.8918D 01	5.8561D 01	1.1273D 02
2	2	4	3.1584D 02	3.0060D 01	4.5532D 00	3.6192D 01	1.4677D 01	1.0452D 02
3	3	4	3.1584D 02	3.0060D 01	4.5532D 00	3.6192D 01	1.4677D 01	1.0452D 02
4	4	5	1.1171D 02	7.4674D 00	7.4294D 00	4.2355D 00	1.1609D 01	1.1355D 01
5	4	6	7.0046D 01	1.3625D 02	1.2680D 02	1.4065D 02	2.2577D 02	2.4341D 02
6	4	11	1.4842D 02	8.3757D 01	7.0037D 01	1.3635D 02	1.5197D 02	1.8508D 02
7	5	6	1.6335D 02	5.6896D 01	1.0058D 02	1.9910D 01	6.8578D 01	3.6991D 01
8	5	12	8.6975D 01	3.9359D 00	4.8721D 00	1.9596D 00	5.3956D 00	4.2280D 00
9	6	7	2.6560D 02	6.3413D 01	3.4475D 01	2.8610D 01	2.9077D 01	5.2145D 01
10	6	9	1.2436D 02	1.3129D 01	8.7529D 00	6.1044D 00	7.8461D 00	1.2107D 01
11	7	8	2.4536D 02	6.6816D 01	3.6352D 01	1.1219D 01	1.9282D 01	3.3775D 01
12	7	10	1.5700D 02	2.2776D 01	6.1323D 00	8.8224D 00	5.3148D 00	2.0306D 01
13	8	15	1.2963D 02	6.3868D 01	1.7563D 01	2.3297D 01	4.5503D 01	7.2147D 01
14	8	16	1.2963D 02	6.3868D 01	1.7563D 01	2.3297D 01	4.5503D 01	7.2147D 01
15	9	10	1.9740D 02	1.1712D 01	1.9030D 01	8.5807D 00	1.9185D 01	1.3330D 01
16	9	13	7.4033D 01	2.5071D 01	2.5071D 01	1.5472D 01	3.1140D 01	3.1650D 01
17	9	14	3.2384D 02	3.0843D 01	3.0843D 01	7.0184D 00	1.3331D 01	1.5726D 01
18	10	13	8.2147D 01	3.4250D 01	3.4250D 01	1.7167D 01	3.4553D 01	3.5119D 01
19	10	14	1.7703D 02	5.0386D 00	5.0386D 00	3.8367D 00	7.2875D 00	8.5969D 00
20	11	12	1.2459D 02	5.1772D 00	1.7683D 01	1.1539D 01	9.9806D 00	2.9220D 00
21	11	17	6.8668D 01	7.6296D 00	7.6296D 00	2.1170D 01	3.0866D 01	2.9257D 01
22	12	17	8.4060D 01	1.1274D 01	9.4322D 00	2.3444D 01	3.1019D 01	3.5141D 01
23	4	16	1.7867D 02	1.8774D 02	3.1584D 02	1.4211D 02	3.7513D 02	2.1376D 02
24	6	15	9.8503D 01	1.8707D 00	0.0	1.7070D 00	0.0	2.3592D 00
25	6	16	9.8503D 01	1.8707D 00	0.0	1.7070D 00	0.0	2.3592D 00
26	15	19	1.4615D 02	4.0674D 01	1.1699D 01	1.6735D 01	5.3538D 01	5.0271D 01
27	16	20	1.4615D 02	4.0674D 01	1.1699D 01	1.6735D 01	5.3538D 01	5.0271D 01
28	5	20	1.3192D 02	2.4593D 01	6.8833D 00	3.2277D 01	3.5086D 01	1.2030D 02
29	5	19	1.3192D 02	2.4593D 01	6.8833D 00	3.2277D 01	3.5086D 01	1.2030D 02
30	7	9	1.1414D 02	0.0	0.0	0.0	0.0	0.0
31	18	21	6.4868D 00	2.7854D 01	2.7854D 01	3.3471D 01	7.7572D 01	8.5696D 01
32	5	11	8.6799D 01	0.0	0.0	0.0	0.0	0.0

Figure C-10 Airplane A 21 Mass, 32 Member Math Model Frequency Data

```
VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

          XGDOT              YGDOT              ZGDOT
            P'                 Q'                 R'
           PHI'              THETA'              PSI'

       5.400000D 02        0.0                0.0
       0.0                 0.0                0.0
       0.0                 0.0                0.0

GENERALIZED SURFACE DATA

BETA =  45.0 DEGREES
XGIN =    0.0
ZGIN =    0.0


MODEL PARAMETERS

VEHICLE WT = 1.601800D 05

VEHICLE CG POSITION
X (FS) =  3.610930 01
Y (BL) =  0.0
Z (WL) =  4.155810 00

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 9.049770 03
I(YY) = 1.015880 04
I(ZZ) = 1.618660 04

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG = -2.928970 01
ZCG = -4.374680 01
```

Figure C-11. Airplane A 21 Mass, 32 Member Math Model Initial Conditions, Overall Mass and c.g. properties

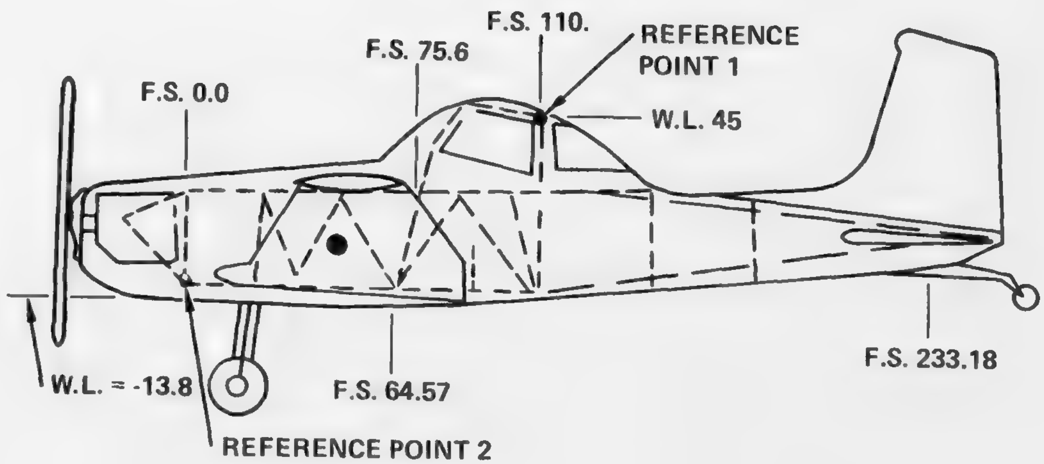

Figure C-12. Profile View of Airplane B

TABLE C-8. AIRPLANE B STRUCTURE TEST LOAD-DEFLECTION DATA

Structure	Design Load (lb.)	Deflection at Design Load (in.)	Rotation at Design Load (deg.)
Engine Mount[e]			
longitudinal	716	NA	
side	1221	.24	.75 (yaw)[d]
vertical	3489	.65	2.03 (pitch)[d]
Main Landing Gear[f]			
longitudinal	2427	2.44[j]	NA
side	2475	NA[j]	NA
vertical	7755	NA	NA
Tail Gear[g]			
longitudinal	542	NA	NA
side	794	4.04	NA
vertical	2364	3.06	NA
Wing[i]			
bending	921,365[a]	10.25[b]	3.17 (roll)
torque	73,200	3.44[b]	6.33 (pitch)
shear	8,616	10.25	3.17 (roll)
Tailcone Bending[h]			
vertical	802	4.75	1.48 (pitch)[c]
side	918	4.04	1.26 (roll)[c]

(a) Units: in-lb

(b) Measured at wing station 238 Front spar, relative to wing station 192

(c) Referenced to F.S. 49

(d) Referenced to F.S. 0.0

(e) Loads points are: (F.S. 18.35, W.L. 3.9, LBL 3.8), deflection and rotations referenced to F.S. 0.0.

(f) Loads points are: (F.S. 17.84, W.L. 44.95, LBL 47.97), deflection and rotations referenced to F.S. 0.0.

(g) Loads points are: (F.S. 26.4, W.L. 4.76, BL 0.0), deflection and rotations referenced to F.S. 0.0.

(h) Loads points are: (F.S. 217.0, W.L. 47.47), deflections and rotations measured relative to F.S. 49.

(i) Airplane axes apply for all structures except wing.

(j) NA means not available

TABLE C-9. AIRPLANE B FUSELAGE TEST VERTICAL LOAD-DEFLECTION DATA

Fuselage Station F.S.	Design Load (lb)	Deflection at Design Load (in)	Rotation at Design Load (deg)
-12.18	7603	1.68	.52
33.58	1544	1.25	.39
59.15	2359	1.81	.56[a]
96.63	1479	2.11	.66
157.61	163	3.00	.93

(a) Referenced to F.S. 49 (pitch direction)

TABLE C-10. AIRPLANE B FILM ANALYSIS DATA

Time, Milliseconds	Reference Point 1(b) V_L (ft/sec)(e)	Reference Point 1(b) V_V (ft/sec)(f)	Reference Point 2(c) V_L (ft/sec)(e)	Reference Point 2(c) V_V (ft/sec)(f)	Rotation, (σ) Degrees (g)	Rotational Velocity ($\dot{\sigma}$) (Deg/sec) (g)
875.0	44.55	0.60	44.55	0.60	28.19 (a)	0.0
750.0	39.92	-0.60	39.92	2.34	29.31	14.64
625.0	39.92	1.15	39.92	2.88	30.83	7.92
500.0	34.16	-2.26	37.27	3.39	33.98	33.84
375.0	31.65	-4.98	33.66	3.32	39.87	40.08
250.0	28.21	-3.21	36.78	5.88	46.08	62.88
125.0	22.28	-3.56	35.65	5.08	55.15	80.64
0.0 (d)	13.73	-4.90	35.31	2.45	66.80	119.28
-125.0	14.57	-1.98	27.69	1.98	79.20	72.24
-250.0	6.26	6.99	19.74	6.00	87.65	69.12
-375.0	7.66	7.53	27.24	4.02	94.64	51.36
-500.0	7.19	0.00	16.77	0.00	100.36	48.96
-625.0	3.83	1.02	21.98	-3.57	106.01	46.56
-750.0	0.96	0.51	14.85	-6.13	114.64	81.60
-875.0	4.31	1.53	14.37	-10.22	124.80	82.76
-1000.0	5.75	-4.60	6.23	-11.76	131.39	30.48
-1125.0	5.27	1.53	22.45	-11.25	139.96	93.10
-1250.0	5.27	0.51	11.98	-15.34	153.57	117.60
-1375.0	8.14	-1.53	8.62	-13.80	167.31	84.96
-1500.0	1.92	-7.16	1.44	-18.91	178.55	83.52
-1540.0	0.48	1.02	0.48	-15.85	182.54	95.76

(a) Initial Reference Rotation angle is 28.19 Degrees. Pitch Angle at anytime $\theta = 28.19°$

(b) Reference Point 1 is located at F.S. 0.0, WL -13.80

(c) Reference Point 2 is located at F.S. 110.0, WL 45.0

(d) Time = 0.0 occurs at nose impact. Negative sign refers to post impact period.

(e) V_L = Longtudinal Velocity (positive in forword direction)

(f) V_V = Vertical Velocity (positive in up direction)

(g) Positive σ indicates nose down pitch

MASS DATA

I	WEIGHTS W	MASS COORDINATES F.S.,W.L.,B.L. X''	Y''	Z''	MASS MOMENTS OF INERTIA (LB-IN-SEC**2) IX	IY	IZ	I
1	1.230000D 02	2.331870 02	0.0	1.500000 01	2.669300 01	3.436000 01	4.266000 01	1
2	3.970000D 01	1.737700 01	-4.042500 01	-4.716500 01	2.310000 01	2.477000 01	1.646700 01	2
3	3.970000D 01	1.737700 01	4.042500 01	-4.716500 01	2.310000 01	2.477000 01	1.646700 01	3
4	1.694000 01	8.925000 01	1.673700 01	-8.963000 00	2.956000 00	4.542000 00	1.396000 00	4
5	1.092500 02	6.457000 01	2.000000 01	-1.027500 01	8.360000 01	1.730000 01	9.113000 01	5
6	4.088000 01	7.209000 01	1.975000 01	2.050000 01	4.750000 00	7.216000 00	6.600000 00	6
7	7.094000 01	2.357000 01	1.802600 01	-8.917000 00	1.386000 02	5.806000 01	1.160000 02	7
8	7.924000 01	2.357000 01	1.932000 01	1.455400 01	1.043300 02	1.008000 01	1.042700 02	8
9	2.200000 01	8.750000-01	1.619000 01	-1.818500 01	3.310000 00	1.068700 01	1.066700 01	9
10	1.112200 02	8.750000-01	1.844000 01	1.184900 01	4.830000 00	2.240400 01	1.910000 01	10
11	5.597000 02	-1.903200 01	0.0	3.072000 00	2.285360 02	2.793860 02	3.536100 02	11
12	9.624000 01	8.750000-01	-1.619000 01	-1.818500 01	2.797000 01	5.250000 01	3.141400 01	12
13	8.920000 01	8.750000-01	-1.844000 01	1.184900 01	4.160000 00	1.661000 01	1.545400 01	13
14	7.094000 01	2.357000 01	-1.802600 01	-8.917000 00	1.717100 02	7.196500 01	1.427700 02	14
15	7.924000 01	2.357000 01	-1.932000 01	1.455400 01	1.695870 02	1.206300 01	1.695870 02	15
16	1.092500 02	6.457000 01	-2.000000 01	-1.027500 01	1.003670 02	2.076000 01	1.093580 02	16
17	7.924000 01	6.457000 01	0.0	-1.027500 01	3.100000 00	5.470000 00	4.777000 00	17
18	3.084000 01	7.209000 01	-1.975000 01	2.050000 01	5.710000 00	8.658000 00	7.928000 00	18
19	1.694000 01	8.925000 01	-1.673700 01	-8.963000 00	2.960000 00	4.542000 00	1.369000 00	19
20	3.000000 01	8.087000 01	0.0	-2.380000 00	2.092000 01	4.360000 01	1.853000 01	20
21	1.385000 01	1.101800 02	-1.375800 01	-7.850000 00	3.196000 00	1.077400 01	9.708000 00	21
22	1.779000 01	1.101800 02	0.0	-7.850000 00	7.393000 00	1.700000 01	1.086300 01	22
23	1.438000 01	1.101800 02	-1.509000 01	2.480000 01	2.963000 00	1.191400 01	1.017800 01	23
24	1.566000 01	8.463000 01	-8.580000 00	4.731000 01	6.845000 00	6.083000 00	4.196000 00	24
25	5.900000 00	1.101800 02	-6.740000 00	4.581000 01	1.175000 00	2.312000 00	2.462000 00	25
26	1.569000 01	8.463000 01	8.580000 00	4.731000 01	6.845000 00	6.083000 00	4.196000 00	26
27	5.910000 00	1.101800 02	6.740000 00	4.581000 01	1.175000 00	2.312000 00	2.462000 00	27
28	9.306000 01	3.358000 01	1.210700 02	-2.500000 00	4.680000 02	3.540000 01	5.020000 02	28
29	1.770000 01	4.300000 01	2.369800 02	1.045000 01	4.500000-01	1.780000 00	2.150000 00	29
30	9.306000 01	3.358000 01	-1.210700 02	-2.500000 00	4.680000 02	3.540000 01	5.020000 02	30
31	1.770000 01	4.300000 01	-2.369800 02	1.045000 01	4.500000-01	1.780000 00	2.150000 00	31
32	1.325000 01	1.101800 02	1.376000 01	-7.850000 00	3.196000 00	1.077400 01	9.708000 00	32
33	1.438000 01	1.101800 02	1.509000 01	2.480000 01	2.963000 00	1.191400 01	1.017800 01	33
34	1.700000 02	8.087000 01	0.0	1.200000 01	4.900000 01	1.470000 02	1.330000 02	34
35	3.450000 01	2.357000 01	0.0	-8.917000 00	1.272000 00	7.656000 00	7.656000 00	35
36	1.650000 01	3.657000 01	1.870000 01	-9.400000 00	6.630000 01	1.853700 01	6.233000 01	36
37	1.650000 01	4.357000 01	1.950000 01	1.750000 01	6.630000 01	1.853700 01	6.233000 01	37
38	9.700000 00	8.154000 01	1.630000 01	2.160000 01	2.300000 00	8.300000 00	4.700000 00	38
39	9.700000 00	1.007000 02	1.860000 01	2.370000 01	2.300000 00	8.300000 00	4.700000 00	39
40	1.650000 01	3.657000 01	-1.870000 01	-9.400000 00	6.630000 01	1.853700 01	6.233000 01	40
41	1.650000 01	4.357000 01	-1.950000 01	1.750000 01	6.630000 01	1.853700 01	6.233000 01	41
42	9.700000 00	8.154000 01	-1.630000 01	2.160000 01	2.300000 00	8.300000 00	4.700000 00	42
43	9.700000 00	1.007000 02	-1.870000 01	2.370000 01	2.300000 00	8.300000 00	4.700000 00	43
44	1.470000 01	2.332000 02	0.0	7.700000 01	6.400000 00	1.420000 01	6.400000 00	44

Figure C-13. Airplane B 44 Mass, 81 Member Math Model Mass Data.

BEAM IJ	BEAM I	BEAM J	MODULUS OF ELASTICITY E	AREA A	MODULUS OF RIGIDITY G	MOMENTS OF INERTIA JX	MOMENTS OF INERTIA I(YY)	MOMENTS OF INERTIA I(ZZ)	LENGTH XLB	DAMPING RATIO CBAR	BEAM IJ	BEAM I	BEAM J
1	1	32	1.0500D 07	1.0105D 00	4.0000D 06	[illegible]	2.5950D 01	6.4900D 00	1.2587D 02	1.0000D-02	1	1	32
2	1	33	1.0500D 07	1.5707D 00	4.0000D 06	[illegible]	4.0710D 01	1.1970D 01	1.2432D 02	1.0000D-02	2	1	33
3	1	21	1.0500D 07	1.0105D 00	4.0000D 06	[illegible]	[illegible].5950D 01	6.4900D 00	1.2567D 02	1.0000D-02	3	1	21
4	1	23	1.0500D 07	1.5707D 00	4.0000D 06	[illegible]	4.0710D 01	1.1970D 01	1.2432D 02	1.0000D-02	4	1	23
5	2	14	3.0000D 07	3.4362D 00	1.1000D 07	[illegible]	1.8900D-01	5.1216D 00	4.4755D 01	1.0000D-02	5	2	14
6	3	7	3.0000D 07	3.4362D 00	1.1000D 07	[illegible]	1.8900D-01	5.1216D 00	4.4755D 01	1.0000D-02	6	3	7
7	4	5	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.4929D 01	1.0000D-02	7	4	5
8	4	32	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.1170D 01	1.0000D-02	8	4	32
9	4	20	2.9000D 07	1.2610D-01	1.1000D 07	1.5200D-02	7.6000D-03	7.6000D-03	1.9842D 01	1.0000D-02	9	4	20
10	5	6	2.9000D 07	1.7830D-01	1.1000D 07	3.8112D [illegible]	3.4756D 00	3.3560D-01	3.1681D 01	1.0000D-02	10	5	6
11	5	36	2.9000D 07	2.9280D-01	1.1000D 07	2.1005D 00	2.0594D 00	4.1100D-02	2.8044D 01	1.0000D-02	11	5	36
12	5	17	2.9000D 07	6.5550D-01	1.1000D 07	8.4027D 00	7.9837D 00	4.1900D-01	2.0000D 01	1.0000D-02	12	5	17
13	6	37	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.8678D 01	1.0000D-02	13	6	37
14	6	18	2.9000D 07	2.1130D-01	1.1000D 07	8.8955D 00	8.4169D 00	4.7860D-01	3.9500D 01	1.0000D-02	14	6	18
15	6	26	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.1635D 01	1.0000D-02	15	6	26
16	6	38	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	1.0120D 01	1.0000D-02	16	6	38
17	7	8	2.9000D 07	3.1710D-01	1.1000D 07	3.2151D 00	[illegible]	3.1440D 00	2.3507D 01	1.0000D-02	17	7	8
18	7	9	2.9000D 07	3.1810D-01	1.1000D 07	2.3616D 00	2.3226D 00	3.9000D-02	2.4583D 01	1.0000D-02	18	7	9
19	7	30	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.3960D 02	1.0000D-02	19	7	30
20	7	35	2.9000D 07	1.2446D 00	1.1000D 07	8.6407D 01	2.5189D 01	6.1218D 01	1.8026D 01	1.0000D-02	20	7	35
21	8	10	2.9000D 07	2.3510D-01	1.1000D 07	8.7440D-01	6.7800D-01	1.9640D-01	2.2873D 01	1.0000D-02	21	8	10
22	8	15	2.9000D 07	4.6730D-01	1.1000D 07	3.7600D-01	1.8800D-01	1.8800D-01	3.8640D 01	1.0000D-02	22	8	15
23	8	30	2.9000D 07	1.3668D 00	1.1000D 07	5.2627D 00	0.0	4.2171D 00	1.4178D 02	1.0000D-02	23	8	30
24	9	10	2.9000D 07	3.0870D-01	1.1000D 07	3.7600D-02	1.8800D-02	1.8800D-02	3.0118D 01	1.0000D-02	24	9	10
25	9	11	2.9000D 07	3.6230D-01	1.1000D 07	1.9000D-01	9.5000D-02	9.5000D-02	3.3321D 01	1.0000D-02	25	9	11
26	9	12	2.9000D 07	1.2970D-01	1.1000D 07	2.4004D 00	2.3940D 00	6.4000D-03	3.2380D 01	1.0000D-02	26	9	12
27	10	11	2.9000D 07	1.2720D-01	1.1000D 07	1.9000D-01	9.5000D-02	9.5000D-02	2.8519D 01	1.0000D-02	27	10	11
28	10	13	2.9000D 07	7.8600D-02	1.1000D 07	1.0000D-02	5.0000D-03	5.0000D-03	3.6880D 01	1.0000D-02	28	10	13
29	11	12	2.9000D 07	3.6230D-01	1.1000D 07	1.9000D-01	9.5000D-02	9.5000D-02	3.3321D 01	1.0000D-02	29	11	12
30	11	13	2.9000D 07	1.2720D-01	1.1000D 07	1.9000D-01	9.5000D-02	9.5000D-02	2.8519D 01	1.0000D-02	30	11	13
31	12	13	2.9000D 07	1.7920D-01	1.1000D 07	3.6000D-02	1.8000D-02	1.8000D-02	3.0118D 01	1.0000D-02	31	12	13
32	12	14	2.9000D 07	3.1810D-01	1.1000D 07	2.3616D 00	2.3226D 00	3.9000D-02	2.4583D 01	1.0000D-02	32	12	14
33	13	15	2.9000D 07	2.3510D-01	1.1000D 07	8.7460D-01	6.7800D-01	1.[illegible]660D-01	2.2873D 01	1.0000D-02	33	13	15
34	14	15	2.9000D 07	3.1710D-01	1.1000D 07	6.3591D 00	3.215[illegible] 00	3.1440D 00	2.3507D 01	1.0000D-02	34	14	15
35	14	40	2.9000D 07	2.9280D-01	1.1000D 07	2.1005D 00	2.0594D 00	4.1100D-02	1.3026D 01	1.0000D-02	35	14	40
36	14	28	1.0500D 07	1.0240D-01	4.0000D 06	6.3667D 02	2.59[illegible] 01	6.1073D 02	1.3960D 02	1.0000D-02	36	14	28
37	15	41	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.0217D 01	1.0000D-02	37	15	41
38	15	28	2.9000D 07	1.3668D 00	1.1000D 07	5.2627D 00	0.0	4.2171D 00	1.4178D 02	1.0000D-02	38	15	28
39	16	17	2.9000D 07	6.5500D-01	1.1000D 07	8.4027D 00	7.9837D 00	4.190[illegible]	2.0000D 01	1.0000D-02	39	16	17
40	16	18	2.9000D 07	1.7830D-01	1.1000D 07	3.8125D 00	3.4756D 00	3.3690D-0[illegible]	3.1681D 01	1.0000D-02	40	16	18
41	16	19	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600[illegible]	[illegible].4929D 01	1.0000D-02	41	16	19
42	16	42	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	[illegible].0120D 01	1.0000D-02	42	16	42
43	18	24	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	[illegible].1635D 01	1.0000D-02	43	18	24
44	19	20	2.9000D 07	1.2610D-01	1.1000D 07	1.5200D-02	7.6000D-03	7.6000D-03	1.9842D 01	1.0000D-02	44	19	20
45	19	21	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.1170D 01	1.0000D-02	45	19	21
46	21	22	2.9000D 07	6.4900D-02	1.1000D 07	5.6000D-03	2.8000D-03	2.8000D-03	1.3758D 01	1.0000D-02	46	21	22
47	21	23	2.9000D 07	1.2980D-01	1.1000D 07	2.0572D 00	1.9196D 00	1.3760D-01	[illegible]	1.0000D-02	47	21	23
48	23	25	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.2608D 01	1.0000D-02	48	23	25
49	24	25	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.56[illegible] 01	1.0000D-02	49	24	25
50	24	26	2.9000D 07	2.2500D-01	1.1000D 07	9.0910D-01	6.6420D-01	2.4490D-01	1.[illegible]260D 01	1.0000D-02	50	24	26
51	25	27	2.9000D 07	1.1600D-01	1.1000D 07	1.4940D-01	1.4300D-01	6.4000D-03	[illegible]	1.0000D-02	51	25	27
52	26	27	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	[illegible]	1.0000D-02	52	26	27
53	28	29	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	[illegible]	1.0000D-02	53	28	29
54	30	31	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.17[illegible] 02	1.0000D-02	54	30	31
55	32	33	2.9000D 07	1.2980D-01	1.1000D 07	2.0572D 00	1.9196D 00	1.3760D-01	[illegible]	1.0000D-02	55	32	33
56	22	32	2.9000D 07	6.4900D-02	1.1000D 07	5.6000D-03	2.8000D-03	2.8000D-03	1.3760D 01	1.0000D-02	56	22	32
57	23	33	2.9000D 07	1.4640D-01	1.1000D 07	5.6000D-03	2.8000D-03	2.8000D-03	3.0180D 01	1.0000D-02	57	23	33
58	27	33	2.9000D 07	6.4900D-02	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.2608D 01	1.0000D-02	58	27	33
59	14	35	2.9000D 07	1.2446D 00	1.1000D 07	8.6408D 01	2.5189D 01	6.1218D 01	1.8026D 01	1.0000D-02	59	14	35
60	20	34	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	1.4380D 01	1.0000D-02	60	20	34
61	7	36	2.9000D 07	1.7830D-01	1.1000D 07	3.8112D 00	3.4756D 00	3.3560D-01	1.3026D 01	1.0000D-02	61	7	36
62	8	36	2.9000D 07	1.7830D-01	1.1000D 07	3.8112D 00	3.4756D 00	3.3560D-01	2.7261D 01	1.0000D-02	62	8	36
63	36	37	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.7807D 01	1.0000D-02	63	36	37
64	5	37	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.4824D 01	1.0000D-02	64	5	37
65	8	37	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.0217D 01	1.0000D-02	65	8	37
66	38	39	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	1.9411D 01	1.0000D-02	66	38	39
67	33	39	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	1.0169D 01	1.0000D-02	67	33	39
68	32	38	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	4.1158D 01	1.0000D-02	68	32	38
69	32	39	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.3297D 01	1.0000D-02	69	32	39
70	5	38	2.9000D 07	1.4[illegible]40D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.6300D 01	1.0000D-02	70	5	38
71	18	41	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.8678D 01	1.0000D-02	71	18	41
72	16	40	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.8044D 01	1.0000D-02	72	16	40
73	15	40	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.7261D 01	1.0000D-02	73	15	40
74	40	41	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.7807D 01	1.0000D-02	74	40	41
75	16	41	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.4824D 01	1.0000D-02	75	16	41
76	42	43	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	1.9424D 01	1.0000D-02	76	42	43
77	23	43	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	1.0204D 01	1.0000D-02	77	23	43
78	16	42	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.6300D 01	1.0000D-02	78	16	42
79	21	42	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	4.1158D 01	1.0000D-02	79	21	42
80	21	43	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	3.3312D 01	1.0000D-02	80	21	43
81	1	44	1.0500D 07	9.9600D-01	1.1000D 07	6.8900D 01	1.2000D 00	6.7700D 01	6.7000D 01	1.0000D-02	81	1	44

Figure C-14. Airplane B 44 Mass, 81 Member Math Model Member Property Data.

DAMPING TERMS (LB/IN/SEC,TRANSLATIONS (1)-(3) AND LB-IN-SEC,ROTATIONS (4)-(6))

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	32	3.45005D 00	2.40637D-01	4.81181D-01	1.12722D 02	3.94560D 02	2.11482D 02
2	1	33	4.34597D 00	3.34311D-01	6.16531D-01	1.42727D 02	5.03212D 02	2.91959D 02
3	1	21	3.45764D 00	2.41167D-01	4.82241D-01	1.12722D 02	3.94561D 02	2.11497D 02
4	1	23	4.34597D 00	3.34311D-01	6.16531D-01	1.42727D 02	5.03212D 02	2.91963D 02
5	2	14	1.62512D 01	1.53568D 00	2.95005D-01	2.74445D 02	1.95134D 02	8.08027D 02
6	3	7	1.62512D 01	1.53568D 00	2.95005D-01	2.50923D 02	1.77882D 02	7.41580D 02
7	4	5	4.71927D 00	2.20820D-01	2.20820D-01	2.23785D 01	2.66308D 01	5.34617D 01
8	4	32	2.50489D 00	1.38020D-01	1.38020D-01	6.61784D 00	2.34657D 01	2.00876D 01
9	4	20	2.99425D 00	1.28337D-01	1.28337D-01	1.17138D 01	2.26006D 01	2.00152D 01
10	5	6	5.03911D 00	7.55918D-01	2.43264D 00	2.26820D 02	3.53769D 02	2.08895D 02
11	5	36	6.28156D 00	2.90708D-01	2.05781D 00	2.22085D 02	3.50637D 02	1.02154D 02
12	5	17	1.36258D 01	1.88688D 00	8.23642D 00	2.05164D 02	1.26723D 03	3.05335D 02
13	6	37	2.96701D 00	1.20681D-01	1.20681D-01	1.90203D 01	2.63014D 01	4.30341D 01
14	6	18	3.39561D 00	4.48176D-01	1.87948D 00	1.25417D 02	3.21590D 02	9.03753D 01
15	6	26	2.80494D 00	1.03425D-01	1.03425D-01	7.20225D 00	1.74769D 01	1.67727D 01
16	6	38	4.68938D 00	5.40515D-01	5.40515D-01	1.08034D 01	3.32438D 01	2.52717D 01
17	7	8	7.80289D 00	3.62075D 00	5.44493D-01	3.63706D 02	1.84646D 02	6.52484D 02
18	7	9	6.01189D 00	2.96630D-01	2.28913D 00	2.42687D 02	5.50874D 02	9.73692D 01
19	7	30	6.29746D 00	2.19248D 00	4.51852D-01	8.42203D 02	1.37308D 03	6.73345D 03
20	7	35	1.47916D 01	1.99357D 01	1.27878D 01	1.13163D 03	3.01148D 03	4.32409D 03
21	8	10	7.67039D 00	1.06179D 00	1.97279D 00	1.35558D 02	2.11748D 02	2.21526D 02
22	8	15	7.58950D 00	4.31567D-01	4.31567D-01	3.07907D 01	2.48673D 02	2.48646D 02
23	8	30	7.06546D 00	3.03238D-01	0.0	9.58246D 01	0.0	9.08627D 02
24	9	10	6.40598D 00	1.81827D-01	1.81827D-01	1.27954D 01	1.53548D 01	3.09496D 01
25	9	11	1.37871D 01	7.33971D-01	7.33971D-01	8.66849D 01	1.67903D 02	2.05758D 02
26	9	12	3.77277D 00	8.96591D-02	1.73407D 00	1.43563D 02	3.27579D 02	1.96497D 01
27	10	11	9.48321D 00	9.95459D-01	9.95459D-01	8.98117D 01	2.04356D 02	2.36720D 02
28	10	13	3.58289D 00	8.48802D-02	8.48802D-02	6.82246D 00	7.52018D 00	1.47434D 01
29	11	12	1.46405D 01	7.79402D-01	7.79402D-01	9.05231D 01	1.99839D 02	2.13553D 02
30	11	13	9.32629D 00	9.78986D-01	9.78986D-01	8.93054D 01	2.03056D 02	2.35515D 02
31	12	13	5.75842D 00	2.09910D-01	2.09910D-01	1.57208D 01	2.98494D 01	4.37382D 01
32	12	14	8.06310D 00	3.97838D-01	3.07016D 00	2.87565D 02	7.40121D 02	1.14380D 02
33	13	15	7.21337D 00	9.99032D-01	1.85525D 00	1.70947D 02	1.99341D 02	2.71542D 02
34	14	15	7.80289D 00	3.62075D 00	3.66146D 00	6.09078D 02	1.47173D 03	7.25099D 02
35	14	40	7.68555D 00	7.65730D-01	5.42032D 00	4.10554D 02	8.16566D 02	1.73300D 02
36	14	28	1.14411D 00	2.19248D 00	4.51852D-01	9.00938D 02	1.41010D 03	6.67786D 03
37	15	41	4.56467D 00	2.63376D-01	2.63376D-01	4.12763D 01	3.41537D 01	9.40164D 01
38	15	28	7.06546D 00	3.03238D-01	0.0	9.85263D 01	0.0	9.56292D 02
39	16	17	1.36206D 01	1.88688D 00	8.23642D 00	2.20201D 02	1.38435D 03	3.33089D 02
40	16	18	4.86770D 00	7.31617D-01	2.34989D 00	2.48525D 02	3.87527D 02	2.29408D 02
41	16	19	4.71927D 00	2.20820D-01	2.20820D-01	2.44491D 01	2.86909D 01	5.84841D 01
42	18	42	4.19825D 00	4.83905D-01	4.83905D-01	1.14639D 01	3.47935D 01	3.09549D 01
43	18	24	2.54306D 00	9.37688D-02	9.37688D-02	7.60284D 00	1.83128D 01	1.81196D 01
44	19	20	2.99425D 00	1.28337D-01	1.28337D-01	1.17135D 01	2.26019D 01	1.99654D 01
45	19	21	2.52964D 00	1.39382D-01	1.39382D-01	6.61992D 00	2.34654D 01	2.00637D 01
46	21	22	2.11792D 00	1.10765D-01	1.10765D-01	7.05280D 00	9.99972D 00	1.39376D 01
47	21	23	1.83577D 00	2.00371D-01	7.48396D-01	7.42279D 01	1.29568D 02	6.65732D 01
48	23	25	1.98662D 00	1.02499D-01	1.02499D-01	9.11420D 00	1.18733D 01	2.18470D 01
49	24	25	1.92271D 00	8.74036D-02	8.74036D-02	6.75585D 00	1.58725D 01	1.41422D 01
50	24	26	3.51478D 00	7.40243D-01	1.21907D 00	5.32534D 01	1.56802D 02	7.45465D 01
51	25	27	1.74765D 00	1.05491D-01	4.98650D-01	1.50164D 01	3.40107D 01	1.04151D 01
52	26	27	1.92449D 00	8.74847D-02	8.74847D-02	6.75585D 00	1.58725D 01	1.41416D 01
53	28	29	5.65288D 00	2.34806D 00	4.83916D-01	6.30721D 02	1.31687D 03	6.61125D 03
54	30	31	5.65288D 00	2.34806D 00	4.83916D-01	6.30721D 02	1.31687D 03	6.61124D 03
55	32	33	1.81615D 00	1.98231D-01	7.40403D-01	7.42279D 01	1.29568D 02	6.65733D 01
56	22	32	2.09759D 00	1.09686D-01	1.09686D-01	7.05279D 00	9.99899D 00	1.39364D 01
57	23	33	2.04763D 00	3.25036D-02	3.25036D-02	4.41067D 00	5.05079D 00	9.36165D 00
58	27	33	1.32304D 00	1.02524D-01	1.02524D-01	9.11420D 00	1.18733D 01	2.18470D 01
59	14	35	1.47916D 01	1.99357D 01	1.27879D 01	1.25454D 03	3.34903D 03	4.787[illegible]D 03
60	20	34	7.82763D 00	6.34553D-01	6.34553D-01	3.92342D 01	1.01040D 02	6.11976D 01
61	7	36	5.99743D 00	2.18809D 00	7.04157D 00	5.13112D 02	9.75978D 02	4.01757D 02
62	8	36	4.33806D 00	7.56267D-01	2.43377D 00	3.20937D 02	4.13756D 02	3.11090D 02
63	36	37	2.28504D 00	9.58536D-02	9.58536D-02	2.56347D 01	3.25735D 01	6.02477D 01
64	5	37	3.98596D 00	1.33515D-01	1.33515D-01	2.52627D 01	2.81794D 01	5.78238D 01
65	8	37	4.56467D 00	2.63376D-01	2.63376D-01	3.51031D 01	3.30262D 01	7.96907D 01
66	38	39	2.09695D 00	1.26010D-01	1.26010D-01	6.02558D 00	2.55327D 01	1.92586D 01
67	33	39	3.22786D 00	3.70278D-01	3.70278D-01	1.01398D 01	3.73448D 01	3.34626D 01
68	32	38	1.56632D 00	4.43912D-02	4.43912D-02	5.99036D 00	1.88406D 01	1.35600D 01
69	32	39	1.74143D 00	6.10060D-02	6.10060D-02	7.77647D 00	1.93980D 01	1.40747D 01
70	5	38	3.79705D 00	1.22015D-01	1.22015D-01	1.93384D 01	2.45207D 01	4.26937D 01
71	18	41	2.69497D 00	1.09616D-01	1.09616D-01	1.91490D 01	2.70276D 01	4.34452D 01
72	16	40	4.44174D 00	1.84752D-01	1.84752D-01	2.94409D 01	3.29673D 01	6.66685D 01
73	15	40	3.93089D 00	1.68197D-01	1.68197D-01	3.53130D 01	2.96266D 01	8.14251D 01
74	40	41	2.28504D 00	9.58536D-02	9.58536D-02	2.56347D 01	3.25735D 01	6.01991D 01
75	16	41	3.98596D 00	1.33515D-01	1.33515D-01	2.66913D 01	2.95089D 01	6.10363D 01
76	42	43	2.09630D 00	1.25892D-01	1.25892D-01	6.03785D 00	2.55131D 01	1.92499D 01
77	23	43	3.22233D 00	3.68377D-01	3.68377D-01	1.01853D 01	3.71883D 01	3.34159D 01
78	16	42	3.79705D 00	1.22015D-01	1.22015D-01	2.11051D 01	2.62201D 01	4.67178D 01
79	21	42	1.58666D 00	4.49675D-02	4.49675D-02	5.99037D 00	1.88405D 01	1.36420D 01
80	21	43	1.76365D 00	6.17566D-02	6.17566D-02	7.77606D 00	1.93375D 01	1.47303D 01
81	1	44	4.90618D 00	2.25999D 00	3.00887D-01	4.89783D 02	1.25658D 02	7.79150D 02

Figure C-15. Airplane B 44 Mass, 81 Member Math Model Damping Data.

BEAM UNCOUPLED,UNDAMPED FREQUENCIES (CPS)

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	32	7.7778D 01	5.4249D 00	1.0848D 01	2.9556D 01	6.9712D 01	3.2365D 01
2	1	33	9.7169D 01	7.4747D 00	1.3785D 01	3.8050D 01	8.6769D 01	4.4031D 01
3	1	21	7.7607D 01	5.4130D 00	1.0824D 01	2.9558D 01	6.9712D 01	3.2365D 01
4	1	23	9.7169D 01	7.4747D 00	1.3785D 01	3.8050D 01	8.6769D 01	4.4031D 01
5	2	14	4.5117D 02	4.2634D 01	8.1900D 00	1.3028D 01	1.1519D 01	4.6736D 01
6	3	7	4.5117D 02	4.2634D 01	8.1900D 00	1.4299D 01	1.2449D 01	5.1244D 01
7	4	5	1.1487D 02	5.3750D 00	5.3750D 00	2.0705D 00	9.4646D 00	4.5985D 00
8	4	32	2.5485D 02	1.4043D 01	1.4043D 01	6.4279D 00	1.2265D 01	1.4405D 01
9	4	20	1.9593D 02	8.3980D 00	8.3980D 00	2.9900D 00	4.8351D 00	7.5155D 00
10	5	6	1.0310D 02	1.5466D 01	4.9771D 01	1.9478D 01	1.1467D 02	1.7846D 01
11	5	36	1.5344D 02	7.1009D 00	5.0265D 01	1.1799D 01	7.7595D 01	5.2973D 00
12	5	17	2.2204D 02	3.0748D 01	1.3422D 02	3.6745D 01	2.2696D 02	2.5335D 01
13	6	37	1.5883D 02	6.4602D 00	6.4602D 00	2.1307D 00	8.1266D 00	4.9673D 00
14	6	18	1.4543D 02	1.9194D 01	8.0494D 01	7.7453D 01	1.9860D 02	4.9503D 01
15	6	26	1.5230D 02	5.6157D 00	5.6157D 00	5.0218D 00	1.0767D 01	1.1950D 01
16	6	38	2.8478D 02	3.2824D 01	3.2824D 01	1.1387D 01	1.7625D 01	2.0653D 01
17	7	8	1.5959D 02	7.4055D 01	1.1136D 01	1.2525D 01	1.1421D 01	4.2239D 01
18	7	9	1.9869D 02	9.8034D 00	7.5654D 01	1.3734D 01	6.3546D 01	6.0659D 00
19	7	30	1.1795D 02	4.1064D 01	8.4629D 00	2.7600D 01	4.5991D 01	8.6782D 01
20	7	35	4.3090D 02	5.8075D 02	3.7253D 02	9.7718D 01	2.6005D 02	2.9000D 02
21	8	10	1.2370D 02	1.7124D 01	3.1816D 01	9.8783D 00	5.1781D 01	1.4301D 01
22	8	15	1.4710D 02	8.3645D 00	8.3645D 00	3.1462D 00	2.5409D 01	7.2252D 00
23	8	30	1.2596D 02	5.4059D 00	0.0	4.2511D 00	0.0	1.2007D 01
24	9	10	1.4770D 02	4.1923D 00	4.1923D 00	6.5371D 00	7.4449D 00	7.6469D 00
25	9	11	7.2802D 01	3.8757D 00	3.8757D 00	2.6178D 00	5.3740D 00	4.7954D 00
26	9	12	9.8008D 01	2.3291D 00	4.5047D 01	2.5697D 01	5.8635D 01	3.7141D 00
27	10	11	4.3416D 01	4.5574D 00	4.5574D 00	2.8204D 00	5.6949D 00	5.1245D 00
28	10	13	5.4911D 01	1.3009D 00	1.3009D 00	2.8990D 00	3.1954D 00	3.3954D 00
29	11	12	6.8558D 01	3.6496D 00	3.6498D 00	2.4888D 00	5.0241D 00	4.6646D 00
30	11	13	4.4147D 01	4.6341D 00	4.6341D 00	2.8244D 00	5.7504D 00	5.1498D 00
31	12	13	9.5382D 01	3.4769D 00	3.4769D 00	3.2196D 00	5.0408D 00	6.1711D 00
32	12	14	1.4814D 02	7.3095D 00	5.6408D 01	1.1578D 01	4.7227D 01	5.1732D 00
33	13	15	1.3154D 02	1.8218D 01	3.3832D 01	7.8308D 00	5.5115D 01	1.1683D 01
34	14	15	1.5959D 02	7.4055D 01	7.4887D 01	1.4861D 01	6.9157D 01	3.5471D 01
35	14	40	2.6998D 02	2.6899D 01	1.9041D 02	1.3739D 01	7.1644D 01	6.7232D 00
36	14	28	2.1428D 01	4.1064D 01	8.4629D 00	2.6876D 01	4.2909D 01	8.4961D 01
37	15	41	1.4645D 02	8.4498D 00	8.4498D 00	1.3928D 00	8.8795D 00	3.2254D 00
38	15	28	1.2596D 02	5.4059D 00	0.0	4.0276D 00	0.0	1.1408D 01
39	16	17	2.2196D 02	3.0748D 01	1.3422D 02	3.3636D 01	2.1146D 02	2.3224D 01
40	16	18	1.0673D 02	1.6041D 01	5.1524D 01	1.7779D 01	1.0468D 02	1.6322D 01
41	16	19	1.1487D 02	5.3750D 00	5.3750D 00	1.8951D 00	8.7937D 00	4.2036D 00
42	18	42	3.1809D 02	3.6664D 01	3.6664D 01	1.0683D 01	1.6859D 01	1.9536D 01
43	18	24	1.6798D 02	6.1940D 00	6.1940D 00	4.8760D 00	1.0277D 01	1.1277D 01
44	19	20	1.9593D 02	8.3980D 00	8.3980D 00	2.9897D 00	4.8351D 00	7.5206D 00
45	19	21	2.5236D 02	1.3905D 01	1.3905D 01	8.4251D 00	1.2265D 01	1.4422D 01
46	21	22	2.0561D 02	1.0753D 01	1.0753D 01	3.2727D 00	4.6401D 00	5.3917D 00
47	21	23	1.9974D 02	2.1802D 01	8.1430D 01	5.3368D 01	8.7224D 01	2.4944D 01
48	23	25	3.0089D 02	1.5524D 01	1.5524D 01	9.9439D 00	1.2315D 01	1.3065D 01
49	24	25	2.7392D 02	1.2452D 01	1.2452D 01	6.7045D 00	1.5047D 01	1.6897D 01
50	24	26	3.4437D 02	7.2528D 01	1.1944D 02	3.2837D 01	9.6687D 01	7.0689D 01
51	25	27	4.5454D 02	2.7437D 01	1.2969D 02	3.6250D 01	8.2104D 01	1.6832D 01
52	26	27	2.7367D 02	1.2441D 01	1.2441D 01	6.7045D 00	1.5047D 01	1.6897D 01
53	28	29	1.5677D 02	6.5117D 01	1.3420D 01	3.4305D 01	7.9646D 01	1.0495D 02
54	30	31	1.5677D 02	6.5117D 01	1.3420D 01	3.4305D 01	7.9646D 01	1.0495D 02
55	32	33	2.0190D 02	2.2037D 01	8.2310D 01	5.3368D 01	8.7224D 01	2.4944D 01
56	22	32	2.0757D 02	1.0854D 01	1.0854D 01	3.2725D 00	4.6398D 00	5.3913D 00
57	23	33	2.1869D 02	3.4714D 00	3.4714D 00	2.9537D 00	3.3824D 00	3.6595D 00
58	27	33	2.0029D 02	1.5521D 01	1.5521D 01	9.9439D 00	1.2315D 01	1.3065D 01
59	14	35	4.3090D 02	5.8075D 02	3.7253D 02	8.7870D 01	2.3457D 02	2.6195D 02
60	20	34	1.2014D 02	9.7455D 00	9.7455D 00	3.0332D 00	4.2185D 00	4.7312D 00
61	7	36	2.1068D 02	7.6864D 01	2.4736D 02	1.9946D 01	1.0117D 02	2.0603D 01
62	8	36	1.3918D 02	2.4263D 01	7.8082D 01	1.5109D 01	1.1441D 02	1.4735D 01
63	16	37	2.1269D 02	8.9220D 00	8.9220D 00	1.5839D 00	6.8784D 00	3.7511D 00
64	5	37	9.7362D 01	3.2613D 00	3.2613D 00	1.3312D 00	6.2517D 00	3.0211D 00
65	8	37	1.4645D 02	8.4498D 00	8.4498D 00	1.6376D 00	9.1820D 00	3.8055D 00
66	38	39	3.3201D 02	1.9951D 01	1.9951D 01	1.0178D 01	1.2303D 01	1.6350D 01
67	33	39	4.1174D 02	4.7232D 01	4.7232D 01	1.3147D 01	1.5404D 01	1.7956D 01
68	32	38	2.0963D 02	5.9413D 00	5.9413D 00	6.3949D 00	7.8823D 00	9.0693D 00
69	32	39	2.3307D 02	8.1650D 00	8.1650D 00	7.1098D 00	8.7635D 00	1.0083D 01
70	5	38	9.8050D 01	3.1508D 00	3.1508D 00	1.7224D 00	7.2449D 00	3.7445D 00
71	[illegible]	41	1.7486D 02	7.1123D 00	7.1123D 00	2.1165D 00	7.9083D 00	4.9201D 00
72	16	40	1.0850D 02	4.5128D 00	4.5128D 00	1.4068D 00	6.6528D 00	3.1828D 00
73	15	40	1.2611D 02	5.3962D 00	5.3962D 00	1.1994D 00	7.6466D 00	2.7776D 00
74	40	41	2.1269D 02	8.9220D 00	8.9220D 00	1.5839D 00	6.8784D 00	3.7511D 00
75	16	41	9.7362D 01	3.2613D 00	3.2613D 00	1.2625D 00	5.9701D 00	2.8562D 00
76	42	43	3.3191D 02	1.9933D 01	1.9933D 01	1.0175D 01	1.2299D 01	1.6345D 01
77	23	43	4.1104D 02	4.6990D 01	4.6990D 01	1.3125D 01	1.5378D 01	1.7925D 01
78	16	42	9.8050D 01	3.1508D 00	3.1508D 00	1.5755D 00	6.7999D 00	3.4323D 00
79	21	42	2.0695D 02	5.8651D 00	5.8651D 00	6.3949D 00	7.8823D 00	9.0693D 00
80	21	43	2.3003D 02	8.0549D 00	8.0549D 00	7.1082D 00	8.7616D 00	1.0081D 01
81	1	44	1.0944D 02	5.0413D 01	6.7117D 00	9.6730D 01	2.0592D 01	1.5388D 02

Figure C-16. Airplane B 44 Mass, 81 Member Math Model Frequency Data.

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VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

        XGDOT              YGDOT              ZGDOT
          P'                 Q'                 R'
         PHI'              THETA'              PSI'

      4.55000D 01        0.0                1.02000D 02
      0.0               -1.56000D 00        0.0
      0.0               -2.83000D 00        0.0

GENERALIZED SURFACE DATA

BETA =   0.0 DEGREES
XGIN =   0.0
ZGIN =   0.0
MODEL PARAMETERS

VEHICLE WT = 2.476790D 03

VEHICLE CG POSITION
X (FS) =  4.06266D 01
Y (BL) = -2.44865D-01
Z (WL) =  2.18869D 00

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG =  0.0
ZCG = -4.08812D 01

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 1.76551D 04
I(YY) = 2.60677D 04
I(ZZ) = 3.95496D 04
```

Figure C-17. Airplane B 44 Mass, 81 Member, Math Model Initial Conditions, Overall Mass, and c.g. Properties

MASS DATA

	WEIGHTS	MASS COORDINATES F.S.,W.L.,B.L.			MASS MOMENTS OF INERTIA (LB-IN-SEC**2)		
I	W	X''	Y''	Z''	IX	IY	IZ
1	1.233000D 02	2.331870D 02	0.0	1.500000D 01	2.669300D 01	3.436000D 01	4.266000D 01
2	3.970000D 01	1.737700D 01	-4.042500D 01	-4.716500D 01	2.310000D 01	2.477000D 01	1.646700D 01
3	3.970000D 01	1.737700D 01	4.042500D 01	-4.716500D 01	2.310000D 01	2.477000D 01	1.646700D 01
4	6.390000D 01	8.925000D 01	0.0	-8.963000D 00	2.683900D 01	5.268000D 01	2.126600D 01
5	3.077000D 02	6.457000D 01	0.0	-1.027500D 01	1.870600D 02	4.353000D 01	2.057000D 01
6	6.176000D 01	7.209000D 01	0.0	2.050000D 01	1.046000D 01	1.566600D 01	1.452800D 01
7	1.533800D 02	2.357000D 01	0.0	-1.150000D 01	3.115920D 02	1.326800D 02	2.614300D 02
8	1.584600D 02	2.357000D 01	0.0	1.455400D 01	2.739170D 02	2.214300D 01	2.738570D 02
9	1.182400D 02	8.750000D-01	0.0	-1.818500D 01	3.128000D 01	6.318700D 01	4.210100D 01
10	2.064200D 02	8.750000D-01	0.0	1.184900D 01	8.990000D 00	3.901400D 01	3.455400D 01
11	5.597000D 02	-1.503200D 01	0.0	4.072000D 00	2.285360D 02	2.793880D 02	3.536100D 02
12	4.480000D 01	1.101800D 02	0.0	-7.850000D 00	1.378500D 01	3.855200D 01	3.027900D 01
13	3.138000D 01	8.463000D 01	0.0	4.731000D 01	1.368900D 01	1.216700D 01	8.393000D 00
14	1.182000D 01	1.101800D 02	0.0	4.581000D 01	2.349000D 00	4.624000D 00	4.924000D 00
15	9.306000D 01	3.358000D 01	1.210660D 02	-2.500000D 00	4.680000D 02	3.540000D 01	5.020000D 02
16	1.770000D 01	4.300000D 01	2.369800D 02	1.045000D 01	4.500000D-01	1.780000D 00	2.150000D 00
17	9.306000D 01	3.358000D 01	-1.210660D 02	-2.500000D 00	4.680000D 02	3.540000D 01	5.020000D 02
18	1.770000D 01	4.300000D 01	-2.369800D 02	1.045000D 01	4.500000D-01	1.780000D 00	2.150000D 00
19	3.300000D 01	3.657000D 01	0.0	-9.400000D 00	1.326000D 02	3.707400D 01	1.246600D 02
20	3.300000D 01	4.357000D 01	0.0	1.750000D 01	1.326000D 02	3.707200D 01	1.246600D 02
21	1.940000D 01	8.154000D 01	0.0	2.160000D 01	4.600000D 00	1.660000D 01	9.400000D 00
22	1.940000D 01	1.007000D 02	0.0	2.370000D 01	4.600000D 00	1.660000D 01	9.400000D 00
23	1.700000D 02	8.087000D 01	0.0	1.200000D 01	4.900000D 01	1.470000D 02	1.330000D 02
24	2.860000D 01	1.101800D 02	0.0	2.480000D 01	5.925000D 00	2.382600D 01	2.035500D 01
25	1.470000D 01	2.332000D 02	0.0	7.700000D 01	6.400000D 00	1.420000D 01	6.400000D 00

Figure C-18. Airplane B 25 Mass, 38 Member Math Model Mass Data

BEAM			MODULUS OF ELASTICITY	AREA	MODULUS OF RIGIDITY	MOMENTS OF INERTIA			LENGTH	DAMPING RATIO
IJ	I	J	E	A	G	JX	I(YY)	I(ZZ)	XLB	CBAR
1	1	12	1.0500D 07	2.0200D 00	4.0000D 06	6.4680D 01	5.1900D 01	1.2980D 01	1.2511D 02	1.0000D-02
2	1	24	1.0500D 07	3.1414D 00	4.0000D 06	1.0536D 02	8.1420D 01	2.3940D 01	1.2340D 02	1.0000D-02
3	2	7	3.0000D 07	3.4362D 00	1.1000D 07	5.3106D 00	1.8900D-01	5.1216D 00	5.4263D 01	1.0000D-02
4	3	7	3.0000D 07	3.4362D 00	1.1000D 07	5.3106D 00	1.8900D-01	5.1216D 00	5.4263D 01	1.0000D-02
5	4	5	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.4715D 01	1.0000D-02
6	4	12	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.0960D 01	1.0000D-02
7	4	23	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.2576D 01	1.0000D-02
8	5	6	2.9000D 07	3.5660D-01	1.1000D 07	7.6224D 00	6.9512D 00	6.7120D-01	3.1680D 01	1.0000D-02
9	5	19	2.9000D 07	5.8560D-01	1.1000D 07	4.2000D 00	4.1188D 00	8.1200D-02	7.8014D 01	1.0000D-02
10	5	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	3.4820D 01	1.0000D-02
11	5	21	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	3.6111D 01	1.0000D-02
12	6	13	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.9598D 01	1.0000D-02
13	6	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.8677D 01	1.0000D-02
14	6	21	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	9.5138D 00	1.0000D-02
15	7	8	2.9000D 07	6.3400D-01	1.1000D 07	3.2111D 00	7.1100D-02	3.1400D 00	2.6054D 01	1.0000D-02
16	7	9	2.9000D 07	6.3400D-01	1.1000D 07	4.7232D 00	4.6452D 00	7.8000D-02	2.3659D 01	1.0000D-02
17	7	15	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.2181D 02	1.0000D-02
18	7	17	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.2181D 02	1.0000D-02
19	7	19	2.9000D 07	3.5660D-01	1.1000D 07	7.6242D 00	6.9512D 00	6.7300D-01	1.3169D 01	1.0000D-02
20	8	10	2.9000D 07	4.7020D-01	1.1000D 07	1.7498D 00	1.3560D 00	3.9380D-01	2.2856D 01	1.0000D-02
21	8	15	2.9000D 07	1.3700D 00	1.1000D 07	5.2626D 00	0.0	4.2170D 00	1.2267D 02	1.0000D-02
22	8	17	2.9000D 07	1.3700D 00	1.1000D 07	5.2626D 00	0.0	4.2170D 00	1.2267D 02	1.0000D-02
23	8	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.0216D 01	1.0000D-02
24	9	10	2.9000D 07	6.1740D-01	1.1000D 07	7.5200D-02	3.7600D-02	3.7600D-02	3.0034D 01	1.0000D-02
25	9	11	2.9000D 07	7.2460D-01	1.1000D 07	1.1400D 00	5.7000D-01	5.7000D-01	2.7357D 01	1.0000D-02
26	10	11	2.9000D 07	7.2460D-01	1.1000D 07	1.1400D 00	5.7000D-01	5.7000D-01	1.7766D 01	1.0000D-02
27	12	21	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	4.1060D 01	1.0000D-02
28	12	22	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	3.2943D 01	1.0000D-02
29	12	24	2.9000D 07	2.5960D-01	1.1000D 07	4.1144D 00	3.8392D 00	2.7520D-01	3.2650D 01	1.0000D-02
30	13	14	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.5594D 01	1.0000D-02
31	14	24	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.1010D 01	1.0000D-02
32	15	16	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.1701D 02	1.0000D-02
33	17	18	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.1701D 02	1.0000D-02
34	19	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.7796D 01	1.0000D-02
35	21	22	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	1.9275D 01	1.0000D-02
36	8	19	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.7254D 01	1.0000D-02
37	22	24	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	9.5436D 00	1.0000D-02
38	1	25	1.0500D 07	9.9060D-01	4.0000D 06	7.0120D 01	1.2000D 00	6.8920D 01	6.2000D 01	1.0000D-02

Figure C-19. Airplane B 25 Mass, 38 Member Math Model Member Property Data

BEAM			MODULUS OF ELASTICITY	AREA	MODULUS OF RIGIDITY	MOMENTS OF INERTIA			LENGTH	DAMPING RATIO
IJ	I	J	E	A	G	JX	I(YY)	I(ZZ)	XLB	CBAR
1	1	12	1.0500D 07	2.0200D 00	4.0000D 06	6.4680D 01	5.1900D 01	1.2980D 01	1.2511D 02	1.0000D-02
2	1	24	1.0500D 07	3.1414D 00	4.0000D 06	1.0536D 02	8.1420D 01	2.3940D 01	1.2340D 02	1.0000D-02
3	2	7	3.0000D 07	3.4362D 00	1.1000D 07	5.3106D 00	1.8900D-01	5.1216D 00	5.4263D 01	1.0000D-02
4	3	7	3.0000D 07	3.4362D 00	1.1000D 07	5.3106D 00	1.8900D-01	5.1216D 00	5.4263D 01	1.0000D-02
5	4	5	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.4715D 01	1.0000D-02
6	4	12	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.0960D 01	1.0000D-02
7	4	23	2.9000D 07	1.4640D-01	1.1000D 07	3.3200D-02	1.6600D-02	1.6600D-02	2.2576D 01	1.0000D-02
8	5	6	2.9000D 07	3.5660D-01	1.1000D 07	7.6224D 00	6.9512D 00	6.7120D-01	3.1680D 01	1.0000D-02
9	5	19	2.9000D 07	5.8560D-01	1.1000D 07	4.2000D 00	4.1188D 00	8.1200D-02	7.8014D 01	1.0000D-02
10	5	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	3.4820D 01	1.0000D-02
11	5	21	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	3.6111D 01	1.0000D-02
12	6	13	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.9598D 01	1.0000D-02
13	6	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.8677D 01	1.0000D-02
14	6	21	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	9.5138D 00	1.0000D-02
15	7	8	2.9000D 07	6.3400D-01	1.1000D 07	3.2111D 00	7.1100D-02	3.1400D 00	2.6054D 01	1.0000D-02
16	7	9	2.9000D 07	6.3400D-01	1.1000D 07	4.7232D 00	4.6452D 00	7.8000D-02	2.3659D 01	1.0000D-02
17	7	15	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.2181D 02	1.0000D-02
18	7	17	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.2181D 02	1.0000D-02
19	7	19	2.9000D 07	3.5660D-01	1.1000D 07	7.6242D 00	6.9512D 00	6.7300D-01	1.3169D 01	1.0000D-02
20	8	10	2.9000D 07	4.7020D-01	1.1000D 07	1.7498D 00	1.3560D 00	3.9380D-01	2.2656D 01	1.0000D-02
21	8	15	2.9000D 07	1.3700D 00	1.1000D 07	5.2626D 00	0.0	4.2170D 00	1.2267D 02	1.0000D-02
22	8	17	2.9000D 07	1.3700D 00	1.1000D 07	5.2626D 00	0.0	4.2170D 00	1.2267D 02	1.0000D-02
23	8	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.0216D 01	1.0000D-02
24	9	10	2.9000D 07	6.1740D-01	1.1000D 07	7.5200D-02	3.7600D-02	3.7600D-02	3.0034D 01	1.0000D-02
25	9	11	2.9000D 07	7.2460D-01	1.1000D 07	1.1400D 00	5.7000D-01	5.7000D-01	2.7357D 01	1.0000D-02
26	10	11	2.9000D 07	7.2460D-01	1.1000D 07	1.1400D 00	5.7000D-01	5.7000D-01	1.7766D 01	1.0000D-02
27	12	21	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	4.1080D 01	1.0000D-02
28	12	22	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	3.2943D 01	1.0000D-02
29	12	24	2.9000D 07	2.5960D-01	1.1000D 07	4.1144D 00	3.8392D 00	2.7520D-01	3.2650D 01	1.0000D-02
30	13	14	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.5594D 01	1.0000D-02
31	14	24	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.1010D 01	1.0000D-02
32	15	16	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.1701D 02	1.0000D-02
33	17	18	1.0500D 07	3.1024D 00	4.0000D 06	6.3667D 02	2.5940D 01	6.1073D 02	1.1701D 02	1.0000D-02
34	19	20	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.7796D 01	1.0000D-02
35	21	22	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	1.9275D 01	1.0000D-02
36	8	19	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	2.7254D 01	1.0000D-02
37	22	24	2.9000D 07	2.9280D-01	1.1000D 07	6.6400D-02	3.3200D-02	3.3200D-02	9.5436D 00	1.0000D-02
38	1	25	1.0500D 07	9.9060D-01	4.0000D 06	7.0120D 01	1.2000D 00	6.8920D 01	6.2000D 01	1.0000D-02

Figure C-19. Airplane B 25 Mass, 38 Member Math Model Member Property Data

DAMPING TERMS (LB/IN/SEC,TRANSLATIONS (1)-(3) AND LB-IN-SEC,ROTATIONS (4)-(6))

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	12	5.43588D 00	3.81527D-01	7.62907D-01	1.85679D 02	7.12836D 02	3.53896D 02
2	1	24	6.49108D 00	5.03042D-01	9.27700D-01	2.11713D 02	8.03128D 02	4.52507D 02
3	2	7	1.94968D 01	1.51953D 00	2.91902D-01	3.01993D 02	2.35108D 02	1.01564D 03
4	3	7	1.94968D 01	1.51953D 00	2.91902D-01	3.01993D 02	2.35108D 02	1.01535D 03
5	4	5	1.15025D 01	5.42884D-01	5.42884D-01	5.02277D 01	7.74389D 01	5.13614D 01
6	4	12	6.75827D 00	3.76121D-01	3.76121D-01	2.38054D 01	8.18861D 01	6.15331D 01
7	4	23	6.75165D 00	3.48850D-01	3.48850D-01	3.04678D 01	8.25387D 01	5.43704D 01
8	5	6	1.14782D 01	1.72190D 00	5.54130D 00	2.16437D 02	7.77621D 02	4.30322D 02
9	5	19	1.46301D 01	6.73669D-01	4.79793D 00	4.59086D 02	7.41545D 02	1.39841D 02
10	5	20	9.27902D 00	3.10845D-01	3.10845D-01	4.18436D 01	5.97152D 01	1.06467D 02
11	5	21	8.92798D 00	2.88396D-01	2.88396D-01	2.30517D 01	5.06471D 01	8.15650D 01
12	6	13	5.79977D 00	2.28574D-01	2.28574D-01	1.51139D 01	3.81974D 01	3.52904D 01
13	6	20	5.93414D 00	2.41375D-01	2.41375D-01	3.81712D 01	5.33264D 01	8.64819D 01
14	6	21	9.67296D 00	1.18599D 00	1.18599D 00	2.15898D 01	7.25045D 01	6.20905D 01
15	7	8	1.51020D 01	4.46859D 00	6.72420D-01	5.38777D 02	1.40015D 02	1.80948D 03
16	7	9	1.47902D 01	7.59571D-01	5.86170D 00	5.46277D 02	1.33560D 03	2.16593D 02
17	7	15	8.26422D 00	3.29745D 00	6.79576D-01	1.21132D 03	1.66559D 03	8.00201D 03
18	7	17	8.26422D 00	3.29745D 00	6.79576D-01	1.21132D 03	1.66559D 03	8.00200D 03
19	7	19	1.23160D 01	4.45081D 00	1.43041D 01	1.06198D 03	2.03906D 03	9.56675D 02
20	8	10	1.48963D 01	2.06620D 00	3.03410D 00	3.08901D 02	4.10313D 02	4.96265D 02
21	8	15	9.18842D 00	4.55232D-01	0.0	1.19761D 02	0.0	1.10252D 03
22	8	17	9.18842D 00	4.55232D-01	0.0	1.19761D 02	0.0	1.10252D 03
23	8	20	9.12953D 00	5.26783D-01	5.26783D-01	7.66326D 01	6.71735D 01	1.74300D 02
24	9	10	1.40310D 01	3.99370D-01	3.99370D-01	2.90602D 01	7.70502D 01	4.83657D 01
25	9	11	2.32304D 01	2.60896D 00	2.60896D 00	2.53240D 02	5.75493D 02	5.43692D 02
26	10	11	3.05754D 01	5.30546D 00	5.30546D 00	2.74810D 02	6.89636D 02	7.32389D 02
27	12	21	3.71099D 00	1.05374D-01	1.05374D-01	1.44425D 01	4.54773D 01	3.28262D 01
28	12	22	4.14399D 00	1.46732D-01	1.46732D-01	1.83373D 01	5.07836D 01	3.06947D 01
29	12	24	4.19625D 00	4.58396D-01	1.71213D 00	1.67556D 02	5.83392D 02	8.77980D 01
30	13	14	3.85394D 00	1.75647D-01	1.75647D-01	1.35266D 01	3.17905D 01	2.83214D 01
31	14	24	4.12467D 00	2.29001D-01	2.29001D-01	1.87490D 01	4.56742D 01	2.46305D 01
32	15	16	5.65278D 00	2.34794D 00	4.83891D-01	6.30706D 02	1.31685D 03	6.61114D 03
33	17	18	5.65278D 00	2.34794D 00	4.83891D-01	6.30706D 02	1.31685D 03	6.61113D 03
34	19	20	4.57103D 00	1.91826D-01	1.91826D-01	5.12949D 01	6.41035D 01	1.21004D 02
35	21	22	4.20876D 00	2.54706D-01	2.54706D-01	1.18818D 01	5.15113D 01	3.86449D 01
36	8	19	7.86279D 00	3.36525D-01	3.36525D-01	6.55098D 01	5.78541D 01	1.51243D 02
37	22	24	6.66652D 00	8.14819D-01	8.14819D-01	1.81666D 01	8.07817D 01	6.90048D 01
38	1	25	4.89819D 00	2.28275D 00	3.01214D-01	2.97954D 02	1.25658D 02	7.86139D 02

Figure C-20. Airplane B 25 Mass, 38 Member Math Model Damping Data

BEAM UNCOUPLED,UNDAMPED FREQUENCIES (CPS)

IJ	I	J	(1)	(2)	(3)	(4)	(5)	(6)
1	1	12	9.9274D 01	6.9677D 00	1.3933D 01	3.6029D 01	7.7800D 01	3.8900D 01
2	1	24	1.3109D 02	1.0159D 01	1.8735D 01	5.1500D 01	1.0984D 02	5.7231D 01
3	2	7	3.1016D 02	2.4173D 01	4.6437D 00	9.0263D 00	8.2000D 00	3.2131D 01
4	3	7	3.1016D 02	2.4173D 01	4.6437D 00	9.0263D 00	8.2000D 00	3.2131D 01
5	4	5	9.5078D 01	4.4874D 00	4.4874D 00	1.8708D 00	6.4051D 00	9.7130D 00
6	4	12	1.9082D 02	1.0620D 01	1.0620D 01	4.6614D 00	7.1426D 00	9.5022D 00
7	4	23	8.8664D 01	4.5811D 00	4.5811D 00	2.3244D 00	3.2894D 00	3.7423D 00
8	5	6	9.0527D 01	1.3580D 01	4.3703D 01	1.8423D 01	1.0418D 02	4.2115D 01
9	5	19	1.3190D 02	6.0735D 00	4.3256D 01	1.1432D 01	7.3710D 01	7.6580D 00
10	5	20	8.3656D 01	2.8025D 00	2.8025D 00	1.2893D 00	5.8956D 00	4.3921D 00
11	5	21	8.3838D 01	2.7082D 00	2.7082D 00	1.6350D 00	6.7028D 00	9.4941D 00
12	6	13	1.5746D 02	6.2055D 00	6.2055D 00	5.0877D 00	1.0843D 01	1.1991D 01
13	6	20	1.5883D 02	6.4605D 00	6.4605D 00	2.1236D 00	8.0161D 00	4.9437D 00
14	6	21	2.9371D 02	3.6011D 01	3.6011D 01	1.1363D 01	1.7772D 01	2.0701D 01
15	7	8	1.4874D 02	4.4013D 01	6.6229D 00	7.6584D 00	7.1966D 00	2.5721D 01
16	7	9	1.6725D 02	8.5896D 00	6.6287D 01	1.2737D 01	5.4271D 01	5.6493D 00
17	7	15	1.0300D 02	4.1099D 01	8.4702D 00	2.6063D 01	3.6714D 01	8.3587D 01
18	7	17	1.0300D 02	4.1099D 01	8.4702D 00	2.6063D 01	3.6714D 01	8.3587D 01
19	7	19	2.0297D 02	7.3351D 01	2.3574D 02	1.9057D 01	9.5587D 01	1.9722D 01
20	8	10	1.2749D 02	1.7683D 01	3.2814D 01	8.6834D 00	5.3390D 01	1.2812D 01
21	8	15	1.1220D 02	5.5589D 00	0.0	4.0139D 00	0.0	1.1410D 01
22	8	17	1.1220D 02	5.5589D 00	0.0	4.0139D 00	0.0	1.1410D 01
23	8	20	1.4645D 02	8.4503D 00	8.4503D 00	1.5004D 00	9.0273D 00	3.4798D 00
24	9	10	1.3525D 02	3.8496D 00	3.8496D 00	4.1622D 00	5.9994D 00	6.9273D 00
25	9	11	1.0525D 02	1.1821D 01	1.1821D 01	6.6850D 00	1.3368D 01	1.2438D 01
26	10	11	1.2355D 02	2.1439D 01	2.1439D 01	8.6906D 00	1.7236D 01	1.5610D 01
27	12	21	1.7730D 02	5.0345D 00	5.0345D 00	4.9494D 00	6.5618D 00	7.7361D 00
28	12	22	1.9799D 02	7.0105D 00	7.0105D 00	5.5269D 00	7.3274D 00	8.6388D 00
29	12	24	1.7491D 02	1.9107D 01	7.1367D 01	4.2207D 01	7.4423D 01	2.2116D 01
30	13	14	2.7402D 02	1.2489D 01	1.2489D 01	6.7136D 00	1.5066D 01	1.6918D 01
31	14	24	3.1190D 02	1.7317D 01	1.7317D 01	1.0316D 01	1.2775D 01	1.3553D 01
32	15	16	1.5676D 02	6.5113D 01	1.3419D 01	3.4305D 01	7.9644D 01	1.0495D 02
33	17	18	1.5676D 02	6.5113D 01	1.3419D 01	3.4305D 01	7.9644D 01	1.0495D 02
34	19	20	2.1273D 02	8.9275D 00	8.9275D 00	1.5842D 00	6.8799D 00	3.7519D 00
35	21	22	3.3319D 02	2.0164D 01	2.0164D 01	1.0214D 01	1.2347D 01	1.6408D 01
36	8	19	1.2613D 02	5.3983D 00	5.3983D 00	1.2922D 00	7.7746D 00	2.9969D 00
37	22	24	4.2483D 02	5.1925D 01	5.1925D 01	1.3572D 01	1.5901D 01	1.8535D 01
38	1	25	1.0902D 02	5.0809D 01	6.7044D 00	5.8845D 01	2.0592D 01	1.5526D 02

Figure C-21. Airplane B 25 Mass, 38 Member Math Model Frequency Data

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VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

          XGDOT              YGDOT              ZGDOT
            P'                 Q'                 R'
           PHI'              THETA'              PSI'

      4.550000D 01        0.0                1.020000D 02
      0.0               -1.560000D 00       0.0
      0.0               -2.830000D 00       0.0

GENERALIZED SURFACE DATA

BETA =   0.0 DEGREES
XGIN =   0.0
ZGIN =   0.0
MODEL PARAMETERS

VEHICLE WT = 2.474190D 03

VEHICLE CG POSITION
X (FS) =  4.204140 01
Y (BL) =  0.0
Z (WL) =  2.305090 00

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 1.671440 04
I(YY) = 2.554000 04
I(ZZ) = 3.781000 04

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG =  0.0
ZCG = -4.120430 01
```

Figure C-22. Airplane B 25 Mass, 38 Member Math Model Initial Conditions, Overall Mass and c.g. Properties

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

XGDOT P' PHI'	YGDOT Q' THETA'	ZGDOT R' PSI'
2.590000D 02	0.0	1.950000D 01
0.0	-1.850000D 00	0.0
0.0	-6.730000D-01	0.0

GENERALIZED SURFACE DATA

BETA = 90.0 DEGREES
XGIN = 0.0
ZGIN = 100.0

MODEL PARAMETERS

VEHICLE WT = 2.474190D 03

VEHICLE CG POSITION
X (FS) = 4.11364D 01
Y (FL) = 0.0
Z (WL) = 1.93672D 00

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG = -6.40201D 01
ZCG = -1.48303D 02

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 1.65007D 04
I(YY) = 2.59984D 04
I(ZZ) = 3.84835D 04

Figure C-23. Airplane B 24 Mass, 37 Member Math Model Initial Conditions and Model Parameter Data

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

XGDOT P' PHI'	YGDOT Q' THETA'	ZGDOT R' PSI'
2.59000D 02	0.0	1.95000D 01
0.0	-1.85000D 00	0.0
0.0	-6.73000D-01	0.0

GENERALIZED SURFACE DATA

BETA = 90.0 DEGREES
XG IN = 0.0
ZG IN = 100.0

MODEL PARAMETERS

VEHICLE WT = 2.477090D 03

VEHICLE CG POSITION
X (FS) = 4.15536D 01
Y (BL) = -2.44836D-01
Z (WL) = 1.82251D 00

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG = -6.06664D 01
ZCG = -1.467762D 02

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 1.74411D 04
I(YY) = 2.52001D 04
I(ZZ) = 3.68975D 04

Figure C-24. Airplane B 40 Mass, 80 Member Math Model Initial Conditions and Model Parameter Data

GPO 908-894